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THESIS

DECISION SUPPORT SYSTEMS FOR MOBILE SUBSCRIBER EQUIPMENT COMMUNICATIONS MANAGERS

by

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The United States Army is fielding a new area common-user tactical communications system, Mobile Subscriber Equipment (MSE), that is designed to keep pace with the AirLand Battle. MSE will dramatically change the structure and responsibilities of signal corps units. The network is under centralized control, and many of the planning and management functions are automated at the signal brigade. This thesis looks well below the brigade level. The intermediate commands are no longer as involved in communications planning, and the nodal platoon leader must now be expected to verify data, assimilate large amounts of information, analyze situations, and make decisions without the buffer of the battalion staff.

This paper proposes a Decision Support System to aid the node center, the hub of the system, in performing these functions. The decisions and planning functions of the nodal platoon leader are analyzed, and the DSS capabilities and requirements are presented by developing the three main components of the system—data, dialogue, and models. The proposed DSS is intended to increase the platoon leader's effectiveness in order to provide timely, reliable, and flexible tactical communications on the battlefield.

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Decision Support Systems for Mobile Subscriber Equipment Communications Managers

by

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Submitted in partial fulfillment of the
requirements for the degree of

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ABSTRACT

The United States Army is fielding a new area common-user tactical communications system, Mobile Subscriber Equipment (MSE), that is designed to keep pace with the AirLand Battle. MSE will dramatically change the structure and responsibilities of signal corps units. The network is under centralized control, and many of the planning and management functions are automated at the signal brigade. This thesis looks well below the brigade level. The intermediate commands are no longer as involved in communications planning, and the nodal platoon leader must now be expected to verify data, assimilate large amounts of information, analyze situations, and make decisions without the buffer of the battalion staff.

This paper proposes a Decision Support System to aid the node center, the hub of the system, in performing these functions. The decisions and planning functions of the nodal platoon leader are analyzed, and the DSS capabilities and requirements are presented by developing the three main components of the system—data, dialogue, and models. The proposed DSS is intended to increase the platoon leader's effectiveness in order to provide timely, reliable, and flexible tactical communications on the battlefield.

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LIST OF ABBREVIATIONS

ACU	Area Common User
ADDS	Automated Data Distribution System
ALB	AirLand Battle
BPS	Brigade Planner System
C^2	Command and Control
CD-ROM	Compact Disk Read-Only Memory
CNR	Combat Net Radio
CS	Combat Support
CSS	Combat Service Support
DDM	Data, Dialogue, Model
DSS	Decision Support System
EPLRS	Enhanced Position Location Reporting System
FM	Frequency Modulation
FM	Field Manual
HF	High Frequency
HHC	Headquarters and Headquarters Company
IHFR	Improved High-Frequency Radio
LEN	Large Extension Node
LOS	Line of Sight
METT-T	Mission, Enemy, Troops, Terrain, Time
MILSTAR	Military Strategic Tactical Repeater
MSE	Mobile Subscriber Equipment

MSRT	Mobile Secure Radio Terminal
NATO	North Atlantic Treaty Organization
NC	Node Center
NCS	Node Center Switch
NMF	Node Management Facility
O-A-V	Object-Attribute-Values
OPORD	Operations Order
RAU	Radio Access Unit
RITA	The French Army Prototype for MSE
ROMC	Representations, Operations, Memory Aids, Control
SCC	System Control Center
SCOTT	Single-Channel Objective Tactical Terminal
SEN	Small Extension Node
SHF	Super High Frequency
SINCGARS	Single-Channel Ground and Airborne Radio System
VHF	Very High Frequency

I. INTRODUCTION

A. GENERAL

The modern battlefield can be characterized as an extremely dynamic environment—both soldiers and highly technical weapon systems are employed at critical times and places to engage a hostile threat. Under such conditions, timely and reliable command and control (C^2) systems are essential. These C^2 systems facilitate control of the battlefield by allowing the commander to gain and maintain the initiative (FM 11-30, 1987, p. 1-1).

Admiral Hays points out that mission success may be realized only through the judicious use of a combination of people, organizations, and communications equipment (Hays, 1988, p. 23). This communications equipment must provide the means to transmit large amounts of information to literally all places on the battlefield. Those responsible for the maintenance and set-up of such communications facilities, the communicators, must know the characteristics of the equipment and the best ways to use it, and they must be able to keep it operational during the fast-paced battle (FM 11-50, 1984, p. 1-1).

Since the nature of the battlefield has changed, communications systems cannot simply be placed on high ground and be expected to perform the critical command and control function, much less survive. Communicators must take advantage of current technology to aid in

making critical decisions to keep pace with the current AirLand Battle doctrine.

B. AIRLAND BATTLE DOCTRINE

1. Evolution—Concept to Doctrine

The AirLand Battle doctrine evolved from the "Active Defense" of the 1970s. Military reformers saw that all Army elements, as shown in Figure 1-1, must be integrated for numerically inferior forces to win while outnumbered. Also, by evaluating the potential impact of Warsaw Pact second echelon forces against NATO, it was realized that commanders must substitute maneuver warfare for attrition warfare. Maneuver warfare would allow ground commanders to delay, disrupt, and destroy these forces. Together, the "integrated and extended battlefield" became the AirLand Battle concept and then doctrine. It is an operational concept. It is what the United States Army must do to win battles in contemporary warfare. (Bellin, 1987, p. 78; and FM 100-5, 1986)

The four tenets of the doctrine—initiative, depth, agility, and synchronization—provide the basis for a doctrine that seeks not simply to avoid defeat but to win. "Initiative" is concerned with setting the terms of the battle with an offensive spirit. It requires action rather than reaction to aggressively accomplish the mission. "Depth" in the AirLand Battle refers to time, space, and resources. Commanders must strike at the enemy in the deep battle to prevent him from concentrating his firepower and to upset his momentum and plans while rear

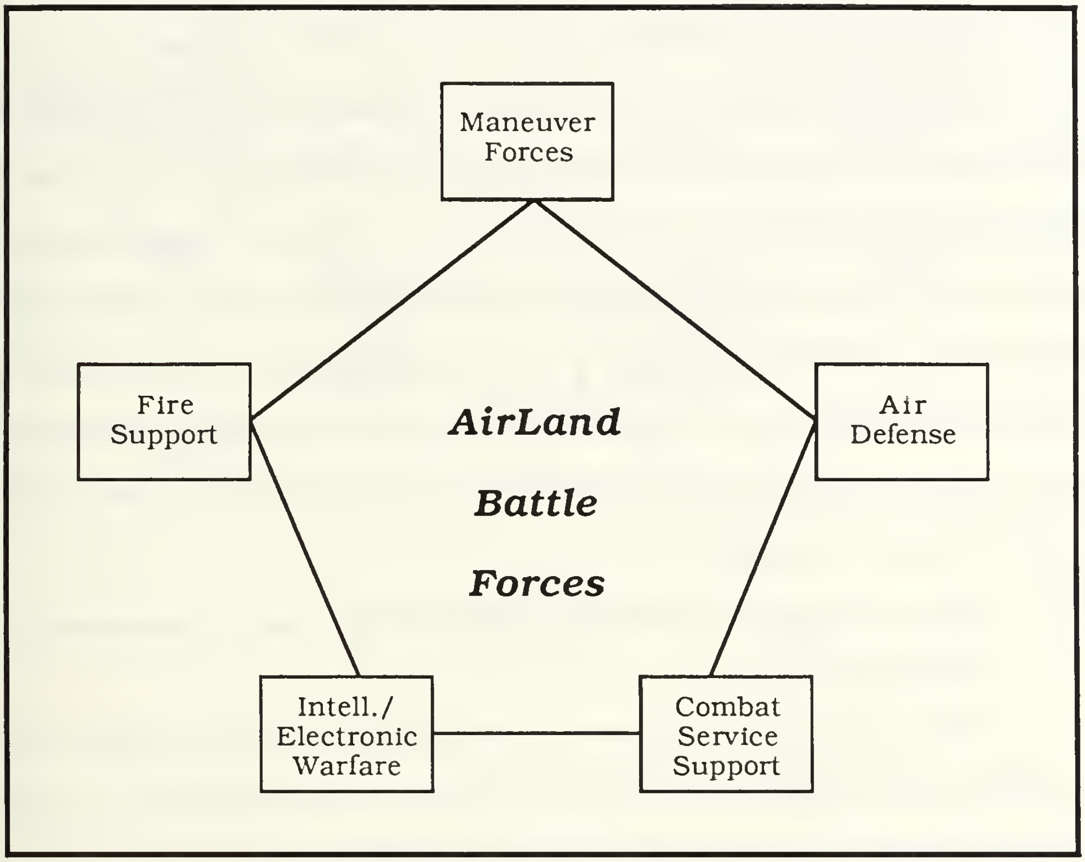


Figure 1-1. **Integration of Elements for Success on the ALB**

area protection is maintained to aid in providing for continuous operations. "Agility" is the ability to act faster than the enemy to exploit his weaknesses and upset his timetable and plans. It implies a constant effort to pit friendly strengths against enemy weaknesses. Finally, "synchronization" requires that the main effort be supported by every means necessary and maintained or shifted as the battle progresses. Of the four tenets, "synchronization" is the most dependent on reliable and flexible communications. (FM 100-5, 1986, and FM 11-30, 1987. FM 100-5, *Operations*, provides a detailed discussion of this subject.)

Time-critical decisions must be made in order to achieve momentum in the attack and to allow for elasticity where required in the defense. This necessitates timely and reliable communications at all levels of the battlefield. This thesis will focus on enhancing communications by providing an automated decision support system to the corps signal battalions' nodal platoon. Specifically, the system will provide communications managers with quick planning guidance to speed system installation, giving field commanders timely and reliable communications support.

2. New Communications Technology for Command and Control

The Army is fielding new communications technology to support the AirLand Battle doctrine. The new communications architecture will support three systems—the Area System, the Combat Net Radio (CNR) System, and the Data System, as shown in Figure 1-2.

The Area System is designed to support the common users from the corps rear boundary and forward to the division maneuver battalion's main command post. CNR provides support for C^2 of maneuver units, combat support units, and combat service support units. The Data System is concerned with data distribution or machine-to-machine traffic on the tactical battlefield.

Mobile Subscriber Equipment (MSE) is the answer to making the Area System a reality. Chapter III will discuss MSE in more detail, as aiding MSE managers will be the target for this thesis.

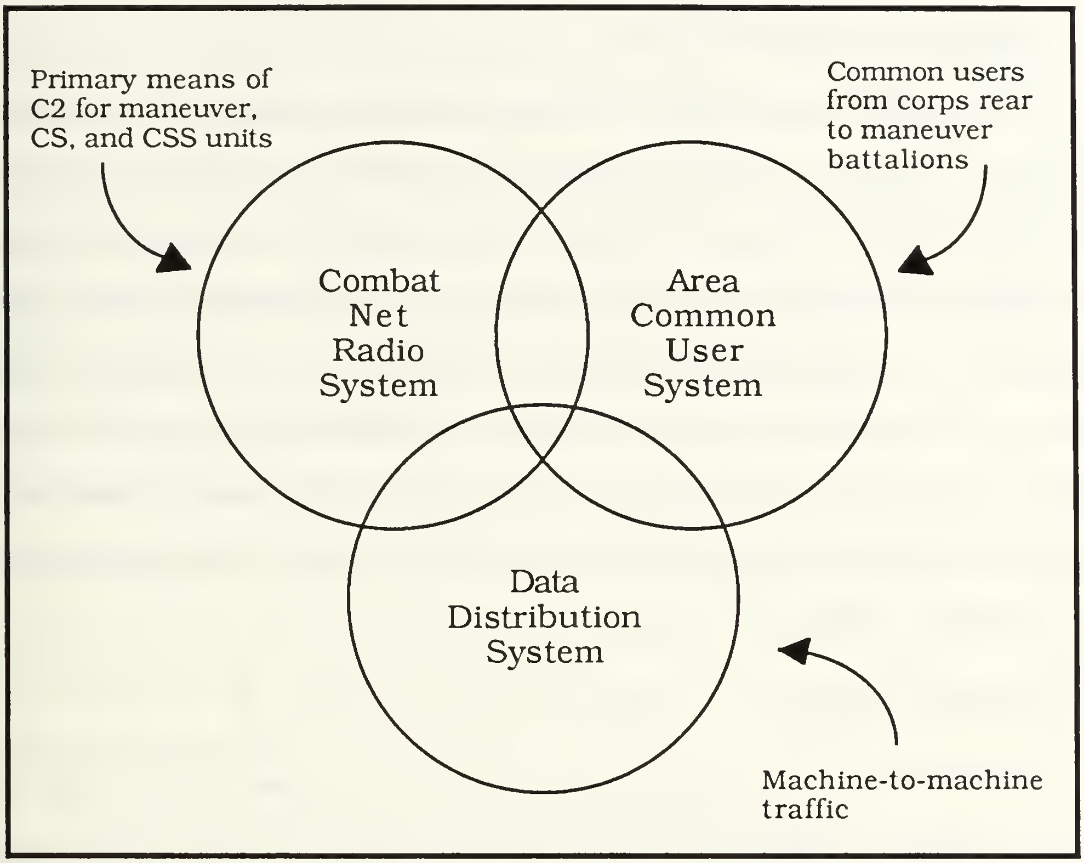


Figure 1-2. **Communications Architecture for the 1990s**

These three new systems can yield improvements in the ground commander's ability to assimilate more information, make better decisions, and act quickly to maintain the upper hand. Advancements in communications will improve effectiveness in command and control by providing a smooth flow of information. In order for the Signal Corps to effectively keep pace with its own advancing technology and increased requirements, Decision Support Systems (DSS) are needed. DSS can help plan, manage, and control the communication links between friendly forces.

C. BENEFITS OF THE STUDY

Today, communications planning and management is performed manually, requires days to weeks to complete, and often contains errors. With DSS, these functions can be reduced to hours and minutes with increased accuracy. This increase in timeliness and effectiveness of communications support is the only way to enable combat forces to keep up with the fast-paced AirLand Battle doctrine. This thesis is intended to provide input to the "evolutionary process" of providing reliable and timely communications with the new communication system, MSE.

D. THESIS SCOPE

This research will be concerned with the analysis and design of a tactical communication DSS for MSE managers at a corps area signal battalion's nodal platoon. Many of the planning and management functions at the brigade level will be automated with MSE; this thesis will look well below that level. Specifically, research will be conducted in an area where manual efforts are still used for making decisions on such problems as site selection, line-of-sight profiling, mission analysis, terrain analysis, and troubleshooting.

E. THESIS ORGANIZATION

Chapter II will focus on Decision Support System concepts in order to ground this research on existing theory. Along with this theoretical examination, a survey of existing DSS that support tactical C^2 will be presented. If one looks both inside and outside of the Signal

Corps, there are several existing automated decision aids to serve as a foundation for tactical communication DSS design. Chapter III will examine the Army's new communications architecture with emphasis on Mobile Subscriber Equipment (MSE). This discussion will also include the decision-making environment for low-level MSE managers. Chapter IV will present the analysis and design for a proposed tactical communications DSS prototype. It will focus on top-level architectural and data design issues: database requirements, model management, and user interface. Potential problems with implementation will also be discussed. Chapter V will make conclusions about DSS use for aiding decision makers who control tactical communication systems.

II. DSS CONCEPTS AND DECISION SUPPORT FOR C^2

A. INTRODUCTION

This chapter examines the theoretical aspects of Decision Support Systems (DSS) and also looks at several "real world" DSS with tactical command and control (C^2) applications. It sets the backdrop for the thesis research. The first section of this chapter examines basic DSS concepts. The second section looks at analysis and design for DSS. The final section presents a survey of several DSS that support tactical C^2.

B. DSS CONCEPTS

The concept of DSS was first articulated in the early 1970s. Since then, there have been many attempts to define DSS, but there is still no universally accepted definition. Part of the DSS identity crisis is that the label, itself, indicates that any system supporting a decision, in any way, is a DSS. Well, what is a DSS, then?

1. What is a DSS?

Many researchers, instead of attempting to establish a definition, have developed capabilities and characteristics of DSS. The characteristics approach taken by Alter, Keen, Sprague, and others includes several distinctive attributes (Sprague, 1986):

- They are aimed at unstructured problems that upper-level managers typically handle.
- They are computerized, easy to use, and interactive.

- They combine the use of models with traditional data access and retrieval functions.
- They are flexible and adaptable to accommodate changes in the environment and the experience of the user.

Sprague, however, points out that DSS is required at all levels of management, not simply at the top levels, and it may require frequent coordination between several levels of the organization (Sprague, 1986).

2. Decision Classes Supported

a. Decision Structure

A DSS should support all phases of the decision structure continuum—from structured to unstructured. Most automated decision support is designed for structured decisions, but increasing efforts are being directed at the ill-defined decisions. Keen says that DSS should focus on assisting managers in tasks that are complex and cannot be routinized (Keen, 1980). Simon described these unprogrammed decisions as those that cannot be described in detail before making the decision. In fact, experience and heuristics are used to make the decision or solve the problem.

There can be many reasons why a decision may be of an unstructured nature. For example, it may be unstructured because of novelty, time constraints, lack of information, large search space, or need for nonquantifiable data (Sprague and Carlson, 1982, p. 94). Parts of the decision can be delegated to the computer, while other parts of the decision require the judgment of the manager to make qualitative trade-offs and subjective assessments (Keen, 1980).

John Little, however, supports development of analytical models to replace the manager's judgment to generate an optimal plan. This idea assumes the decision can be structured in the traditional methods of operations research and management science fields. (Stabell, 1987, p. 245)

b. *Level of Managerial Activity*

Several authors contend DSS tend to be directed at helping upper-level managers where problems are typically less well structured. More recent views realize DSS is not exclusively aimed at top management and, in fact, all decision levels of the organization are supported by DSS. Sprague used Robert Anthony's classification scheme to describe four decision levels (Sprague, 1982):

- Strategic Planning: Decisions related to setting policies, choosing objectives, and selecting resources.
- Management Control: Decisions related to assuring effectiveness in acquisition and use of resources.
- Operational Control: Decisions related to assuring effectiveness in performing operations.
- Operational Performance: Decisions that are made in performing the operations.

c. *Degree of Uncertainty*

DSS must also support the varying degrees of uncertainty. Ahituv and Neumann explain three categories of decision uncertainty as: deterministic, probabilistic, and random. Deterministic decisions are made when all information is known with certainty. Probabilistic decisions are usually semi-structured where conditions and outcomes can be stated in terms of probabilities. Finally, random decisions are

made when events are highly unstructured and their probabilities cannot be specified.

The first two degrees of uncertainty are easily supported with DSS by use of such operations research techniques as deterministic models and probabilistic or stochastic models. However, DSS that support random decisions are the most difficult to construct and have not been successfully implemented.

3. Levels of Support

a. The Decision-Making Process Phases

DSS should support all phases of the decision-making process. A modified version of Simon's model in Figure 2-1 shows the relationship of DSS support to the decision-making process.

b. Active or Passive Support

Whether a DSS is active or passive depends on the type of user interface. With passive support, there is no attempt to change existing methods of making decisions. The passive or responsive system is unable to take independent action without the express direction of the user. (Isett, 1987, p. 80; Elam, 1987)

Keen points out, however, that most DSS provide a somewhat more active type of support. The active support system is the equivalent of a staff assistant that not only answers "what if" questions but can initiate interaction on its own (Keen, 1987, p. 257). The DSS would prompt for inputs, recommend courses of action, and possibly comment on the user's decision making (Isett, 1987, p. 80).

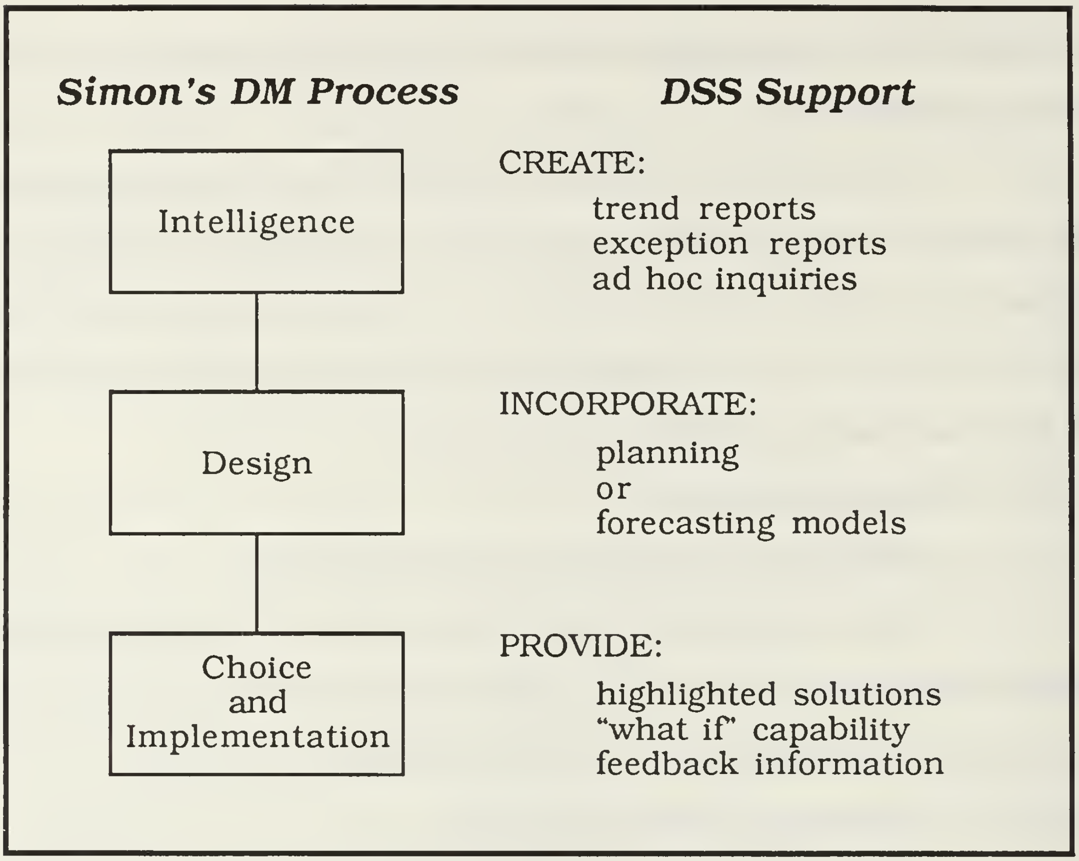


Figure 2-1. **Decision-Making Process Supported by DSS**

In Figure 2-2, Elam and Isett summarized some of the roles and responsibilities of the user and the DSS considering the responsive versus directive support approach. Elam and Isett felt that the terms "responsive" and "directive" were better descriptors of the type of exchange between user and system. (Elam, 1987, p. 10)

C. ANALYSIS AND DESIGN FOR DSS

Because the nature of the DSS is different from Management Information Systems (MIS) and transaction processing systems, the

	Directive DSS	Responsive DSS
System	Recognize a problem exists. Initiate interaction. Respond to user queries. Develop suggested solutions. Intellectually engage the user.	Respond to user queries. Provide operations for user to develop solutions. Provide modules for user to evaluate solutions.
User	Respond to system queries. Evaluate system suggestions. Approve courses of action. Implement solutions.	Recognize a problem exists. Develop alternative solutions. Select preferred solutions. See solution implemented.

Figure 2-2. **Summarization of DSS/User Roles and Responsibilities** (Elam, 1987, p. 10)

traditional development methodologies are inappropriate for building DSS. The next few sections discuss the current development practices for DSS.

1. Current Perspectives on DSS Development

Hogue and Watson pointed out that many alternative development methodologies are in practice: adaptive, evolutionary, heuristic, and middleout (Hogue and Watson, 1984). These approaches contain some common elements, and these elements are discussed below.

Small, tentative systems should be built, used, and modified as required, suggesting an iterative and evolutionary approach. One of the reasons that designers build provisional systems that are repeatedly modified is that it is difficult to define functional requirements of the DSS. An essential portion of the DSS life cycle is that the user and designer will gain insight about the decision task and environment,

thereby identifying new requirements (Alavi and Napier, 1984). In the adaptive design approach, the typical development steps of the standard life cycle are combined and repeated until the operational system is "completed."

Another common element among development perspectives is the idea that there should be a high degree of user involvement in development. User involvement is not a new idea to information system development, but the user was usually nonmanagement and was only involved in the initial definitional stages. With DSS development, many researchers agree there is not only direct management involvement but also user control over the project. (Hogue and Watson, 1984)

Finally, the system should be constructed quickly, using the most current technology available. It is difficult to specify a desired amount of time to complete a DSS because they are continuously evolving. Research of Sprague, Keen,and Scott Morton indicate that it takes days, weeks, or even months to generate an operational system. The fourth-generation languages introduced in the early 1970s enable nonprogrammers to quickly develop customized DSS for specific applications. Current microcomputers are becoming less of a constraint for large-scale DSS requirements because of increased memory and computing power, and video-disk technology is eliminating storage constraints (MacLean, 1986).

2. The ROMC Approach to Analysis

Sprague and Carlson suggest an approach to systems analysis to deal with the poorly specified requirements of DSS. The approach

is based on four user-oriented entities: Representations, Operations, Memory Aids, and Control Mechanisms. It is called the ROMC approach.

a. Representations

DSS should provide decision makers with familiar representations which support familiar conceptualizations. For example, many tactical military planners think in terms of maps when formulating a concept of an operation. These maps are required to even get started on planning. The conceptualization may be mental, but in many cases it is physically represented on scratch paper, greaseboards, or viewgraphs. (Sprague and Carlson, 1982, pp. 100–102)

b. Operations

Simon's "intelligence, design, choice" model, as discussed earlier, can be used to classify the operations used in decision making. For example, during the intelligence phase, some of the operations that may be used include data gathering, identifying objects, or diagnosing problems. The operations may involve such analytical computing as simulation models or forecasting algorithms. (Sprague and Carlson, 1982, pp. 103–104)

c. Memory Aids

DSS should provide both long- and short-term memory aids and should not require the learning of a new command language to use it. It should ease the memory load for the user by aggregating and interpreting information. Below is a list of several types of memory

aids to support the use of representations and operations (Sprague and Carlson, 1982, pp. 104–106):

- A database
- Views
- Work spaces
- Libraries
- Links
- Triggers
- Profiles

d. Control Mechanisms

Control mechanisms are provided for users to handle and use the entire support system. There are a variety of different types of control aids to facilitate the mechanics of using a DSS, to support training and explanation of using a DSS, and to override DSS defaults or procedures. Examples are menus, function keys, natural language error messages, "help" commands, and a "learn by doing" training method. (Sprague and Carlson, 1982, pp. 106–107)

3. Data, Dialogue, Model (DDM) for Design

Figure 2-3 depicts the DDM conceptual model and is helpful in considering the design of DSS components. The DSS generally contains three subsystems: database, dialogue interface, and model base. The sections that follow briefly describe these three components and look at design techniques for these subsystems.

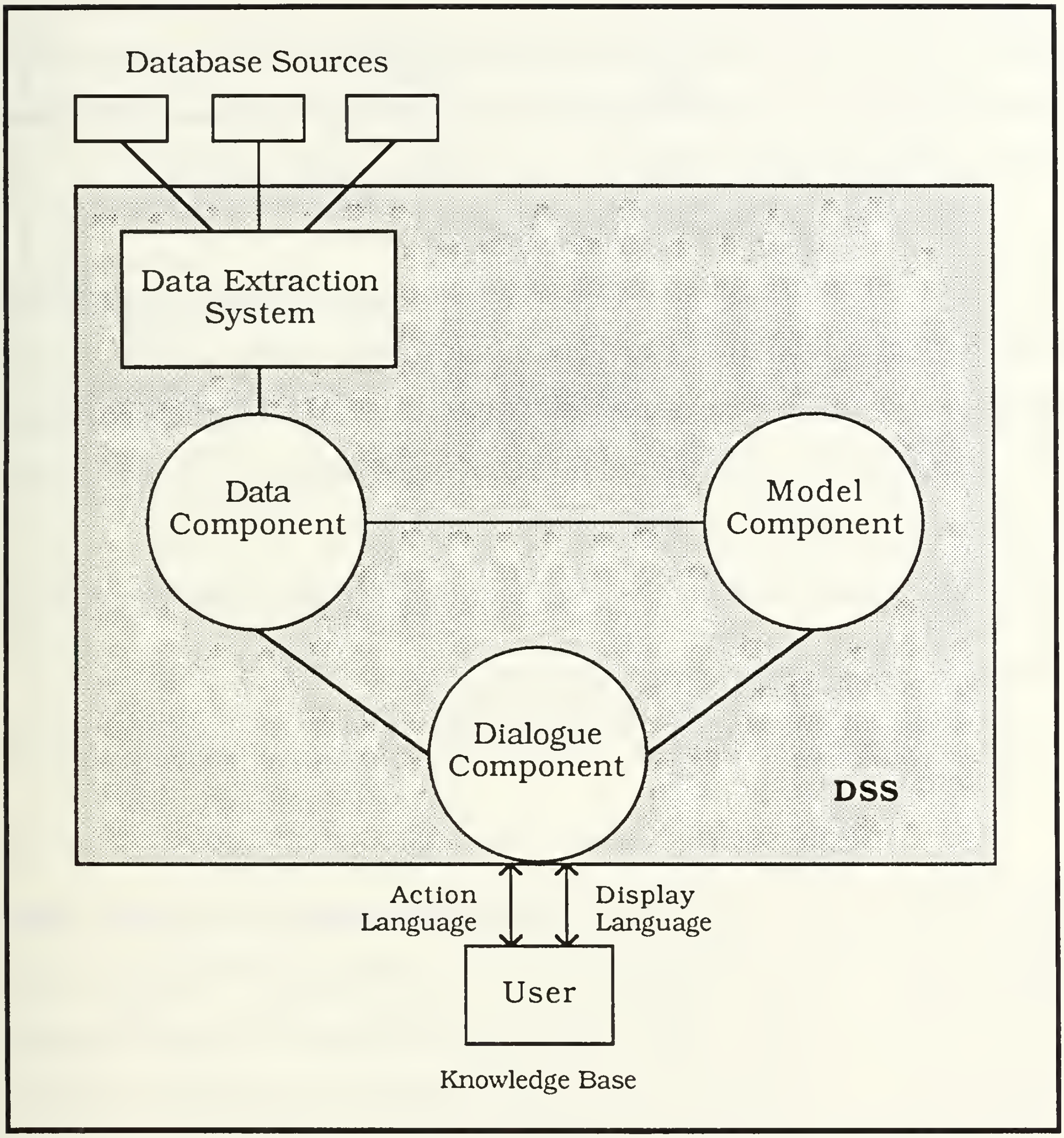


Figure 2-3. **The Data, Dialogue, Model Framework of DSS** (Sprague, 1986)

a. The Data Component

Database management is both a prerequisite and an ingredient for building a DSS. The database provides for the memory requirements of a DSS. Sprague and Carlson proposed a two-level

database connected by an extraction component. The data extraction technique allows for interfacing both internal and external databases with the DSS database. (Sprague and Carlson, 1982, p. 244)

b. The Dialogue Component

The dialogue component is the user-system interface and is the part of a DSS that provides much of the power, flexibility, and usability. It is also a necessary ingredient for DSS success. Sprague cites Bennett's research (Bennett, 1977) by dividing the dialogue into three parts (Sprague, 1986):

- Action language: what the user can do in communicating with the system.
- Display language: what the user sees.
- Knowledge base: what the user must know to effectively use the system.

Design of the dialogue component should focus on the representations and control mechanisms from analysis. The goal of the design should be to provide effectiveness and understandability. The results of the dialogue design should be used to select hardware and software but, as is often the case, the hardware and software might be a given constraint because of availability or cost (Sprague and Carlson, 1982, p. 218). Competition within the microcomputer industry has resulted in a user-system interface explosion, as depicted in Figure 2-4 (MacLean, 1986).

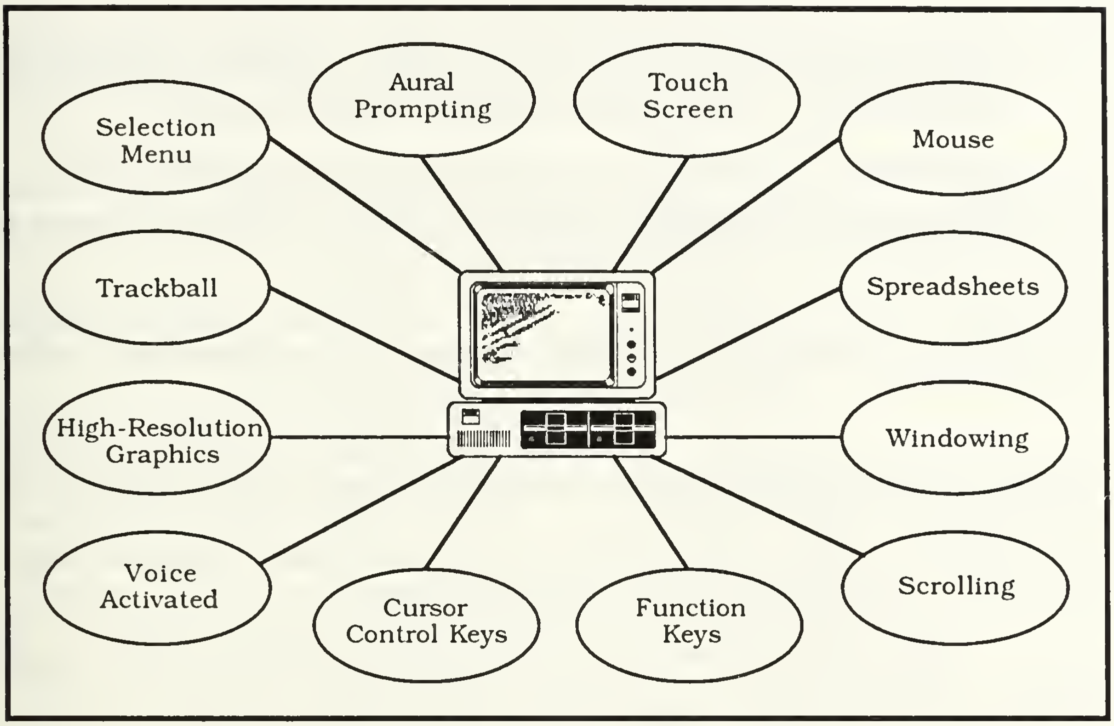


Figure 2-4. **User Interface Explosion** (Maclean, 1986)

c. *The Model Base*

The modeling component gives decision makers the ability to analyze problems completely. The models make use of operations research techniques (e.g., deterministic models, optimization, stochastic models), decision analysis (e.g., utility/value methods, probability models, mixed models), pattern recognition (e.g., discrimination and classification techniques), or knowledge-based techniques (e.g., expert systems, planning and problem solving, pattern-directed inference). (AFCEA, 1988)

From the user's point of view, the models are operations (R**O**MC) that manipulate representations. Sprague and Carlson cite

Barbosa's research (Barbosa and Hirko, 1980) to identify capabilities for use of DSS models. (Sprague and Carlson, 1982, p. 261)

- Interface: The user should be able to work without interruption. Familiar control parameters should be used to allow the user to think only about the problem-solving process.
- Control: The user should be able to set the level of control (manual/automatic) and the system should allow the user to introduce subjective information as the process warrants.
- Flexibility: Operations should be interchangeable, that is, the results of one module can serve as input to any other operation.
- Feedback: The user should have enough feedback to inform him of the state of the solution generation process.

The design must also satisfy several system requirements in order to meet the objectives of DSS. The design requires a set of software functions to manage the model base, and there must be integration of the models with both the dialogue and data components. This full integration is necessary to support the decision-making activities while still allowing close interaction and rapid feedback between user and computer. (Sprague and Carlson, 1982, p. 261)

D. DECISION SUPPORT SYSTEMS FOR TACTICAL COMMAND AND CONTROL

As previously discussed in this chapter, DSS are designed to support "unstructured" decision making. Many proponents of the AirLand Battle concept argue that the fast-paced environment is exactly what computers are best at handling. On the other hand, Adolf von Schell, a World War I German Army captain, described the dynamics of combat (Bellin and Chapman, 1987, p. 91):

> Every soldier should know that war is kaleidoscopic, replete with constantly changing, unexpected, confusing situations. Its problems cannot be solved by mathematical formulae or set rules.

These apparent contradictions in philosophy appear to be in defining the purpose of computers as providing decision support or as decision makers. General John R. Galvin, Supreme Allied Commander, Europe, comments on the use of automated decision support on the battlefield (Galvin, 1988, pp. 27–28):

> We are entering an era in which the analysis and management of the many variables that have to be considered when making decisions in war can be greatly improved by automating the analytical process. Expert systems, which are sophisticated computer programs that analyze large amounts of complex information based upon carefully defined decision rules, are being developed to support the military commander. For example, such systems can be used to help us predict enemy capabilities and likely tactics and to assist in determining appropriate responses based on a rapid, but thorough, assessment of relevant factors. Development of such decision aids that help the commander understand the battle better will contribute to the effective and efficient use of scarce military resources.

The United States military is taking advantage of emerging technology and has developed many interactive decision aids to support tactical decision makers. The purpose of this section is to describe several of the Decision Support Systems that are available to assist tactical C^2. What follows is a brief discussion of several systems in order to see what is being done to help commanders generate, evaluate, and implement plans for combat operations that contribute to the effective and efficient use of personnel and equipment.

1. Brigade Planner System (BPS)

The BPS is a computer-assisted planning aid that brigade command groups can use to evaluate alternative courses of action for

combat operations. It combines existing and new development models into a mobile and compact system of software and hardware that planners can use interactively. Specifically, it allows experimentation with various task organizations, terrain utilization schemes, and options concerning friendly and enemy tactics and threat levels. (TCATA, 1987, p. 6)

As Figure 2-5 suggests, BPS implements the planning process in a cyclical fashion, beginning with terrain analysis and ending with generation of an operations order. It allows the operations officer to invoke any one of seven modules at will or in turn. An entire planning sequence can take six hours and be saved on tape. The earlier in the cycle a module is invoked, the greater the time it takes to execute it. For example, terrain analysis will take three to four hours, while the operations order will take only minutes. (TWTD7, 1986, p. 10)

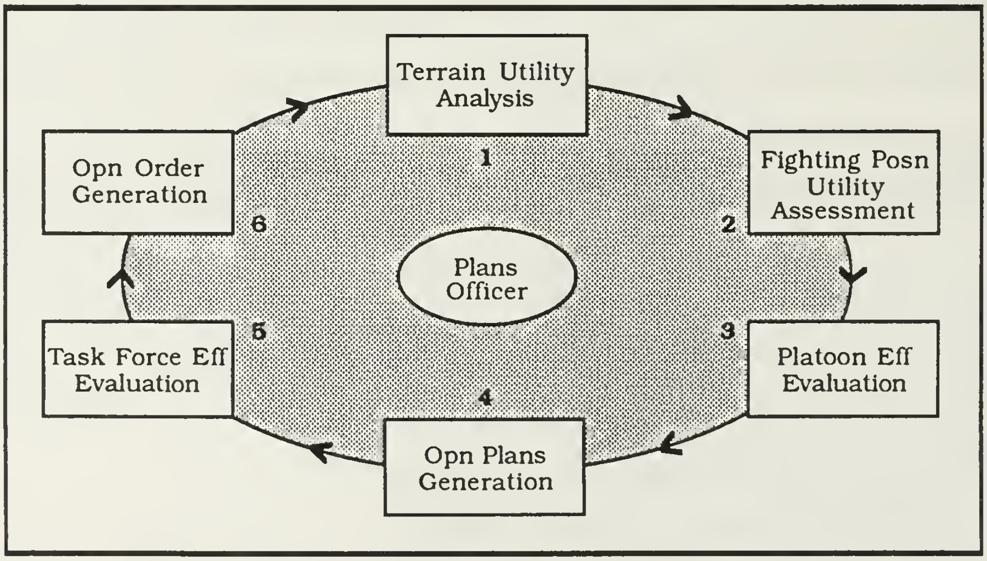


Figure 2-5. **Brigade Planner System Cyclical Planning Process** (TWTD7, 1986)

The system is currently being used by a mechanized infantry division in the Federal Republic of Germany, and a development relationship exists between TRAC-WSMR, the developers, and the users.

2. TACPLAN

TACPLAN represents an attempt to aid corps commanders in the generation and evaluation of plans or "concepts of operation." This aid has a graphics interface that consists of an interactive video disk-based display system linked to an IBM PC/AT. The TACPLAN knowledge bases are oriented to the relationship between terrain type, maneuverability, and unit type. For example, if a planner has driven an armored unit into a marshy area, TACPLAN will warn the planner about the rule violation. TACPLAN'S analytical modules allow comparison of alternative plans by executing several multi-attribute utility routines that are linked directly to the graphic display system. The aid takes on the role of an intelligent staff assistant by working with the planner to fine-tune judgments and hypotheses. Figure 2-6 depicts a conceptual view of TACPLAN. (Andriole, 1986a, p. 858)

TACPLAN has demonstrated the benefit to be gained from flexible graphic representation of the planning environment. It also shows the utility of hybrid analytical methods. (Andriole, 1986a)

3. INTACVAL

INTACVAL was developed from TACPLAN and expects less from the user. It tries to leap from "assistant" to "associate." Figure 2-7 shows a model of INTACVAL. Its functional components include a

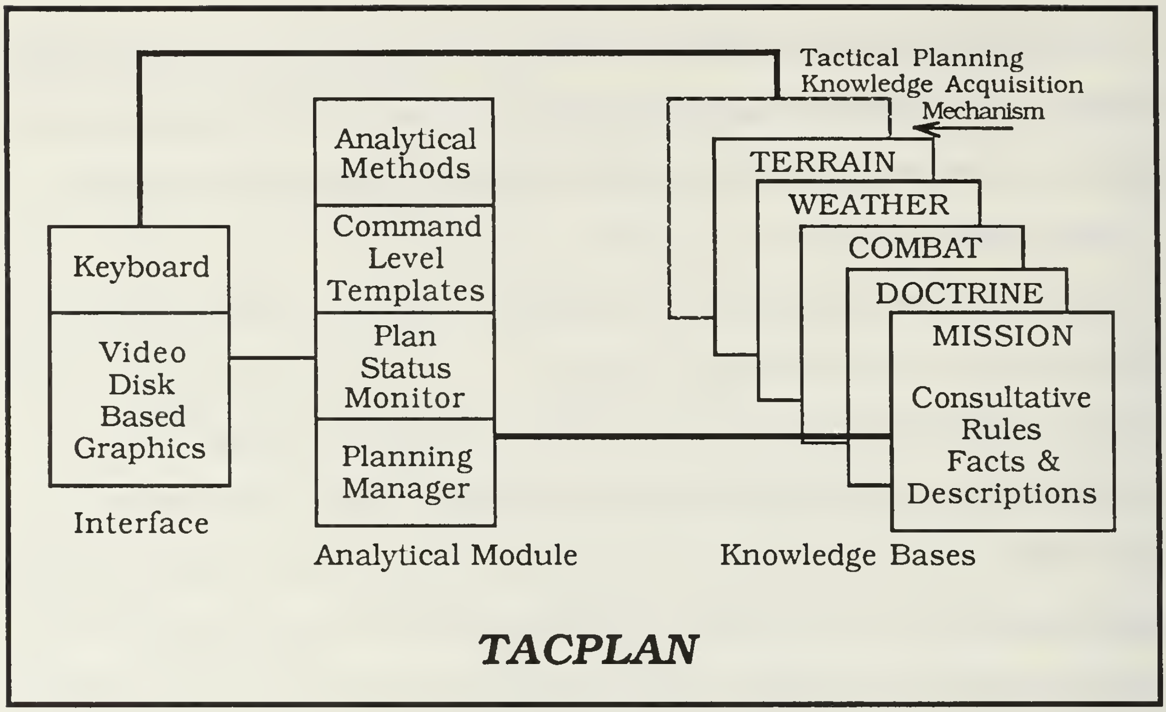


Figure 2-6. **Conceptual View of TACPLAN** (Andriole, 1986a)

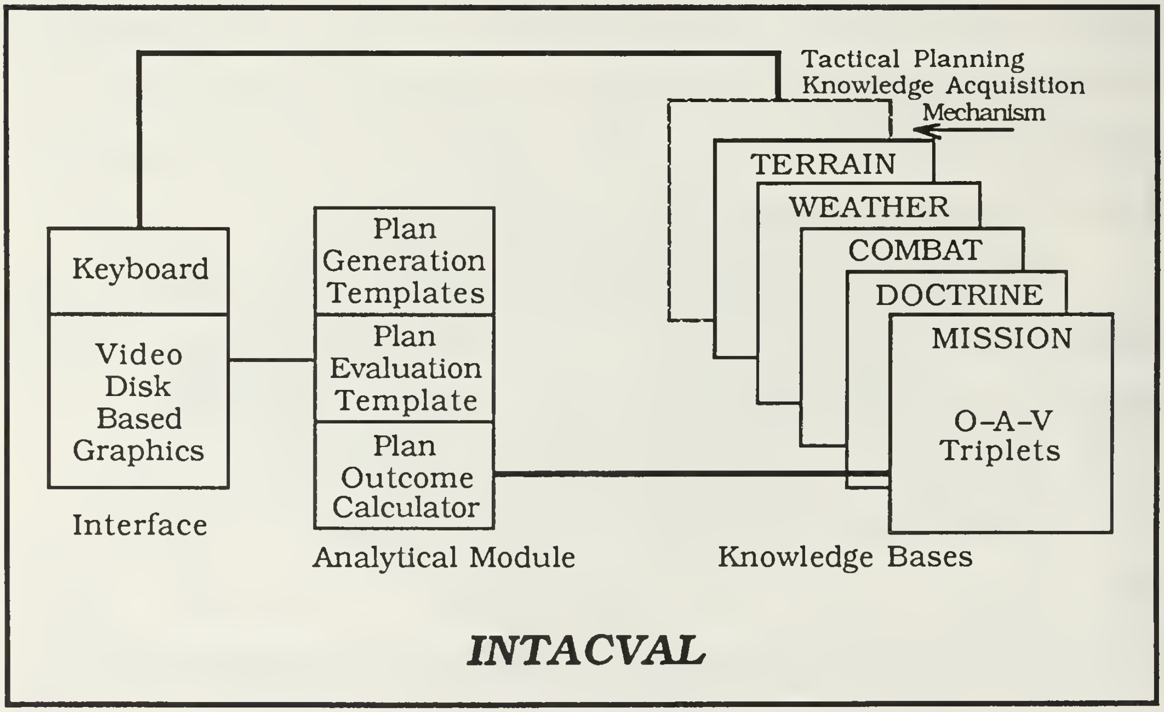


Figure 2-7. **Conceptual View of INTACVAL** (Andriole, 1986a)

planning interface, knowledge bases, plan formulation and evaluation templates, and a plan outcome (battle) calculator. (Andriole, 1986a, p. 860)

Developers adopted the object-attribute-values (O-A-V) structure to capture a great deal of information about planning while keeping the structure flexible, yet formal. Figure 2-8 explains the O-A-V structure. O-A-Vs form the basis of the knowledge base. Various combinations of values relate to specific "concepts of operations" that can be used in the planning process to check planner judgments or to generate alternative plans. (Andriole, 1986a, p. 860)

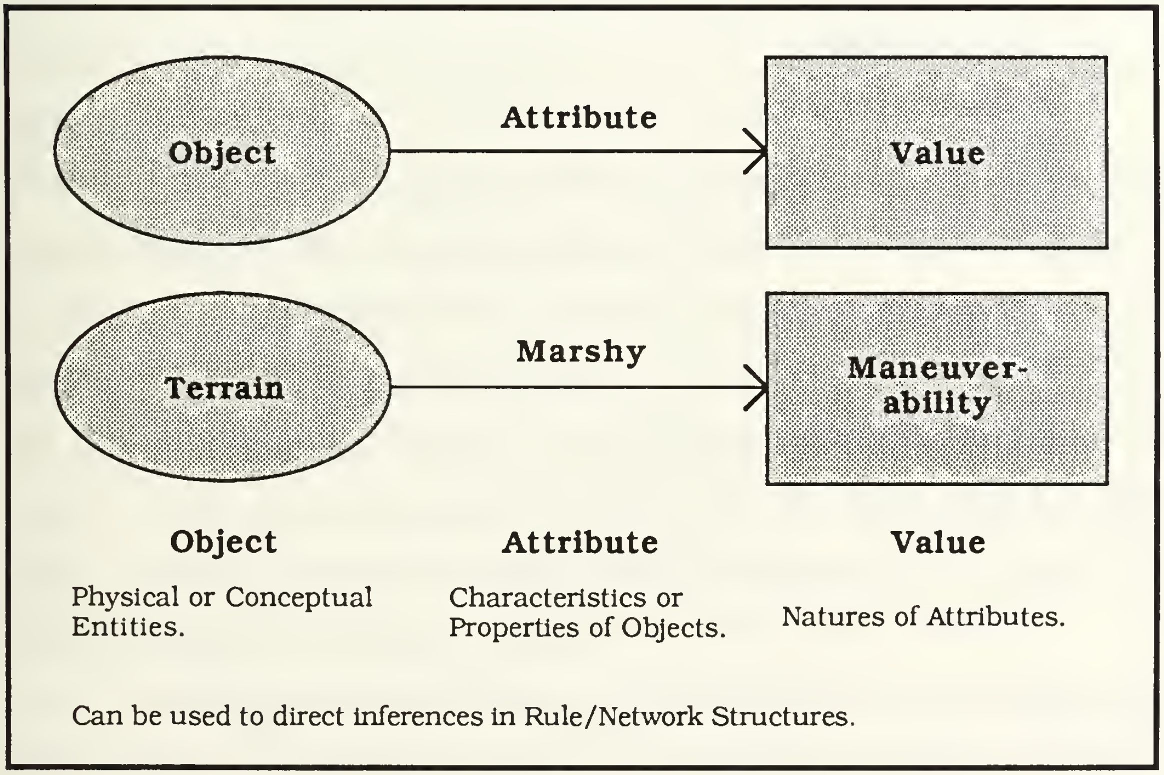


Figure 2-8. **O–A–V's Explanation** (Andriole, 1986a)

The battle calculator checks the plans to determine if they violate any constraints. The planner can then make comparisons across alternatives. The planner's primary function in the INTACVAL aiding process is to iterate on proposals generated by the system, to query INTACVAL about why and how it recommended what it did, and to play out alternatives in real time for further review. (Andriole, 1986a, p. 864)

The objective of TACPLAN and INTACVAL was to change manual planning to computer-aided planning without disturbing the process itself. The researchers concede that both DSS are only small steps in that direction, and the real work lies ahead. (Andriole, 1986a)

4. CONSCREEN

CONSCREEN is another interactive planning aid. It was designed to support military contingency planning for officer students at the United States Army War College and by combat commanders and their staffs. A functional overview of the system can be seen in Figure 2-9. Specifically, the DSS assists planners in (1) evaluating alternative concepts of employment for military operations and (2) surfacing key issues relating to the strategic guidance, assumptions, and forces found in contingency and capabilities plans. (C^2MUG, 1987)

The aid incorporates the planner's judgment, considers the principles of war, and scrutinizes the assumptions underlying the plan. It enhances but does not replace the user's judgment; the planner still

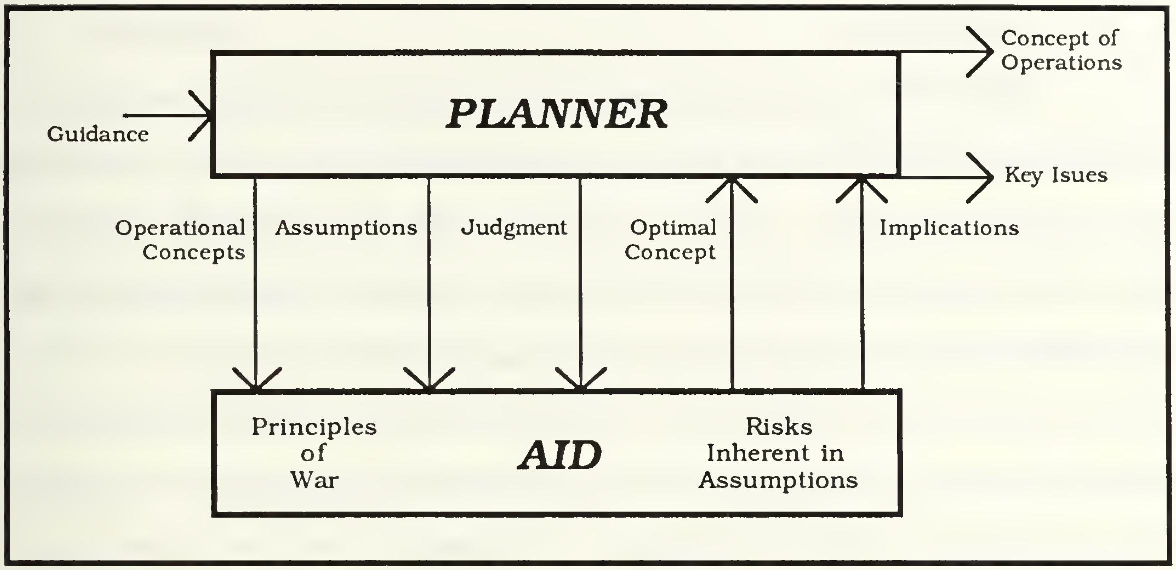


Figure 2-9. **Functional Overview of CONSCREEN** (AFCEA, 1988)

must make the decision. It also helps in the understanding of key issues in the planning guidance and in discovering new plans. (C^2MUG, 1987)

CONSCREEN provides the capability to construct, store, retrieve, analyze, and modify evaluation models of users' judgments regarding the planning task at hand. A prestructured decision template is used to compare alternative concepts across different evaluation criteria using scores and weights provided by the planner. The aid uses these scores and weights to calculate the overall score for each option. The results can be examined using comparative analysis and sensitivity analysis. (C^2MUG, 1987)

The significance of this interactive aid is that it allows the staff officer to personalize the planning process by letting him input personal judgment but still compels him to consider the many facets of established doctrine.

5. AI/ENCOA

AI/ENCOA is a prototype DSS designed to assist intelligence analysts in helping determine enemy courses of action. The system is intended to help these analysts logically and systematically organize and evaluate available information to formulate their assessments and predictions of enemy intentions and activities. (C^2MUG, 1987)

This system uses multi-attribute utility (MAU) models for course-of-action determination. The system was designed to support users, including tactical intelligence analysts in field positions and students in tactical training (C^2MUG, 1987).

Although this aid was designed to improve decision making in the field, it has been restricted to use in a training environment primarily because of two factors. The first reason results from the tendency of decision aids to be time consuming.

> Although it is clear to decision analysts that the improved quality is worth the extra time, this is not accepted by users who have to respond to the time constraints as well as spend the extra cognitive energy required by the decision aids.

The second reason that decision aids have difficulty getting fielded is that "decision makers often refuse to accept that their cognitive and decision making skills need aiding at all." (Phelps, 1986)

It is important to note that, while there have been many support systems developed and demonstrated, most have yet to be fielded or made fully operational. When building a DSS, however, one can still discover usable capabilities or features by studying the aids listed above. One can also learn from the development techniques used.

E. SUMMARY

This chapter has examined the theoretical and "real world" aspects of Decision Support Systems. Although there is no universally accepted definition for DSS, there are many characteristics which have been identified and incorporated into DSS. DSS research will continue to have a significant impact on improving the quality and effectiveness of military leaders by incorporating those proven aspects of DSS in new areas. The discussion suggests that the emerging theory has already been put into practice in several military applications to help commanders get the "upper hand" on the battlefield. The DSS examined in this chapter were designed to support what Keen calls "decisions that really matter." High technology and nontraditional development techniques are being used to support decision makers and planners in tactical C^2 environments that are uncertain, fast-paced, and constantly changing. How can forces be synchronized in this type of environment?

As pointed out in Chapter I, time-critical combat decisions necessitate timely and reliable communications at all levels of the battlefield. These communications facilities allow for "synchronization" of all resources to conduct operations. One should ask, then, whether communicators will be able to keep pace with the AirLand Battle. The answer is unclear, but it is certain that, just as high technology is being used to develop automated decision aids for combat decision makers, DSS are required for tactical communications managers to make fast and effective decisions. The next chapter examines the

communicator's decision-making environment and the Army's new communications architecture designed to keep pace with the combat commander's needs.

III. COMMUNICATIONS TO SUPPORT THE AIRLAND BATTLE

A. INTRODUCTION

As mentioned in Chapter I, the Army is fielding new communications technology to support the AirLand Battle doctrine. This chapter will examine the Army's new communications architecture with emphasis on Mobile Subscriber Equipment (MSE) and its characteristics. This discussion will include the MSE structure, environment, and decision making to provide timely, reliable communications. The new doctrine and operational changes that occur with MSE will be presented to help understand communications managers' responsibilities in planning and controlling networks. It is the improvement of the communications manager's decision-making effectiveness, with Decision Support Systems (DSS), that is the focus of the next chapter.

B. THE ARMY COMMUNICATIONS ARCHITECTURE

In order for a tactical communications system to be successful, it must present a common battlefield scenario to all commanders. The Army has developed a communications architecture to enhance command and control (C^2). The architecture is centered around three types of communications support: Combat Net Radio (CNR) Systems, Automated Data Distribution Systems (ADDS), and the Area Common User (ACU) Network (FM 11-30, 1987, p. 2-1). The next few sections discuss these three systems, with emphasis on MSE.

1. Combat Net Radio (CNR)

CNR's primary role is for voice C^2 within the corps and division maneuver brigades, combat support (CS), and combat service support (CSS) units (FM 11-30, 1987, p. 2-14). CNR also has a secondary role as the alternate for passing data transmissions (FM 11-32, 1987, p. 1-2). CNR is designed around three separate radio systems that have different capabilities and transmission characteristics to ensure that at least one communications system will work at any given time (FM 11-32, 1987, p. 1-2). A brief description of the three systems follows.

a. Single-Channel Ground and Airborne Radio Systems (SINCGARS)

SINCGARS is the replacement radio for all AN/PRC-77 manpack and AN/VRC-12 series vehicular mounted VHF radios. SINCGARS takes advantage of modern digital signal processing technologies. It is jam-resistant, secure, and interoperable with the current family of VHF-FM radios. SINCGARS is the primary communications means for short-range (less than 35 kilometers) secure voice communications for C^2 below division level. It is also heavily used by CS and CSS units throughout the corps. (FM 11-32, 1987)

b. Improved High Frequency Radio (IHFR)

IHFR will selectively replace the current HF manpack and HF vehicular radios. IHFR presents a small electronic signature on the battlefield and is more reliable than the previous radio. It will use both ground and skywave propagation paths for short- and long-range communications requirements. IHFR will support secure voice or low-

speed data systems requiring long-range connectivity. (FM 11-30, 1987; FM 11-32, 1987)

c. *Single-Channel Objective Tactical Terminal (SCOTT)*

SCOTT is a new system that does not replace any current inventory equipment. It is a stand-alone transportable tactical satellite communications terminal that uses the military strategic tactical repeater (MILSTAR) satellite. SCOTT is a tri-service effort to provide joint C^2 and coordination from division through theater/army level. (FM 11-32, 1987)

2. Automated Data Distribution System (ADDS)

ADDS is concerned with machine-to-machine traffic on the tactical battlefield. The primary system for data distribution is the Enhanced Position Location Reporting System (EPLRS). EPLRS is a computer-based system designed to support the Army's battlefield automated systems. It provides near real-time, jam-resistant, secure data distribution and position location navigation reporting for tactical forces. (FM 11-30, 1987)

3. Area Common User (ACU) Network

ACU is designed for a given geographical area and provides a means of staff coordination, administrative/logistics traffic, and personnel reporting for maneuver forces. MSE is the new common-user voice communications system within the corps. It is the backbone of corps communications and is deployed from the corps rear boundary forward to the division maneuver battalion's main command post. MSE will be discussed in detail in the following section.

C. MOBILE SUBSCRIBER EQUIPMENT (MSE)

This section describes MSE, the common-user area communications system for the Army's corps and divisions. The discussion will provide an overview of MSE, the organization of MSE units, and the decision-making environment.

Before the analysis is conducted, a short explanation of the term "subscriber" is in order. Although ths term connotes an assessment of charges for telephone service, as in a civilian telephone system, communications support with MSE is not charged to units. "Subscriber" simply refers to the mobile and static "user" of the network that will receive communications support in accordance with corps standard operating procedures with most information coming from the corps' operations order. Subscriber profiles which indicate the specific system capabilities (e.g., security level, maximum precedence, call forwarding) are placed in the SCC database and can be developed corresponding to an Army unit, a command structure, or a community of interest. (USASC, 1988)

1. MSE Overview

The Army's decision to field MSE was the result of the need to modernize tactical communications in order to keep up with ALB doctrine. The equipment which MSE replaces did not support ALB doctrine. It did not provide the maneuver commander with mobile communications needed to accomplish the mission in a dynamic, rapidly changing battlefield. (FM 11-999F, 1987)

The MSE system is based on a network that provides area communications to a corps composed of three to five divisions and covers a 37,000 square kilometer area (FM 11-999F, 1987). MSE is interoperable with echelons above corps, other military forces, and commercial telephone systems (Kelley, 1986). Figure 3-1 is a depiction of MSE deployment. The backbone of the network is composed of 42 node centers (NCs) connected by line-of-sight multi-channel

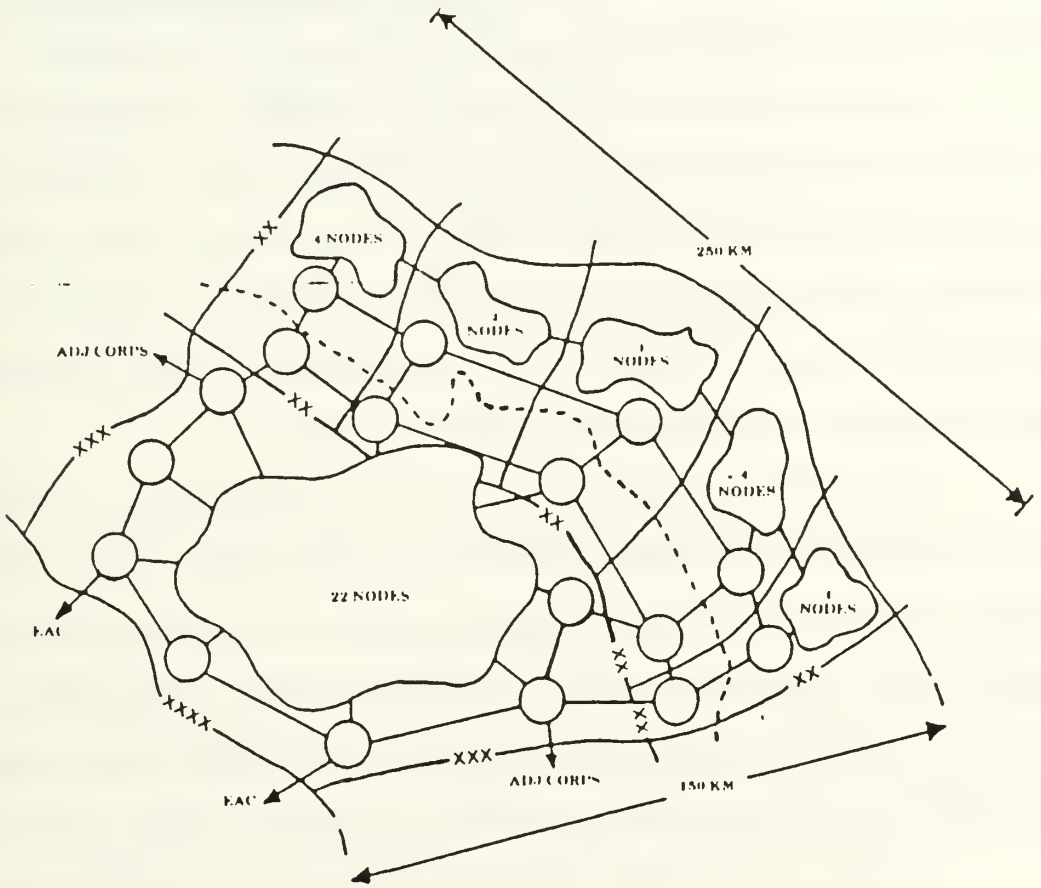


Figure 3-1. **MSE Deployment** (Kelley, 1986)

communications. The system is also comprised of 92 radio access units (RAUs) to allow radio access to the MSE network. Concerning numbers of users, the system provides service for up to 1,900 mobile subscribers and 8,500 wire subscribers. (FM 11-999F, 1987)

In order to support combat units, signal units are placed by the general direction of maneuver and by the location of the combat, CS, and CSS units. NCs and extension nodes are deployed to support a plan as it evolves. As a forward area of the corps battlefield has an increasing need for communications, NCs and extension nodes are redeployed to provide more support in that area. (FM 11-999F, 1987)

Another way to describe MSE is to divide it into three layers, as shown in Figure 3-2. The uppermost layer is the network's backbone structure of NCs. In the middle layer are the large and small extension nodes which provide network access to command posts. The bottom layer of MSE's structure consists of the wireline and mobile radio subscribers. (FM 11-999F, 1987)

This MSE overview now turns to a description of MSE features. MSE provides secure, automatic digitized voice, data, and facsimile communications to wireline users or mobile users. Flood search-based routing is used to make MSE more responsive to the user, more mobile, and easier to install. Flood search also eliminates the need for extensive system engineering. (FM 11-999F, 1987)

Flood searching facilitates engineering by providing a "self-organizing switching network." This routing technique is not

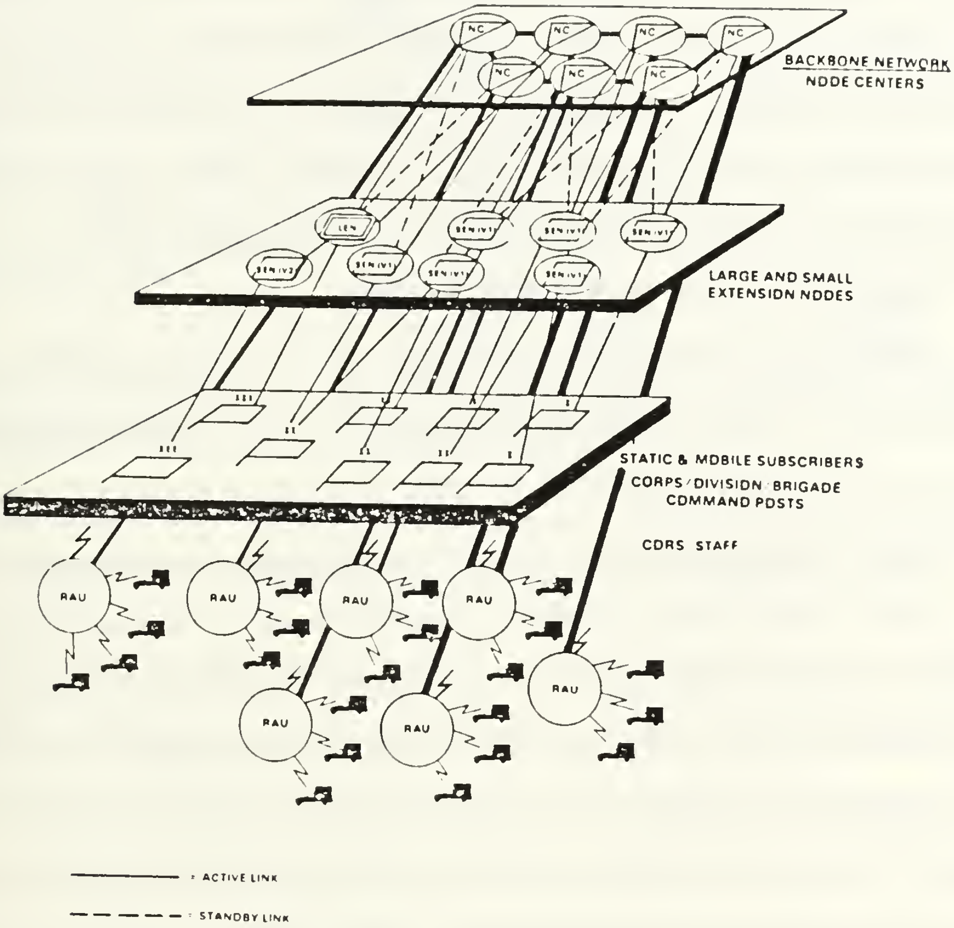


Figure 3-2. **Layers of the MSE Network** (FM 11-999F, 1987)

extremely efficient but is very robust and is well suited for the battlefield environment where several node switches may be destroyed instantly. When a non-local call comes through an NCS, that message is sent out to all adjacent switches and the call is automatically routed to its destination. (FM 11-999E, 1987, pp. 1–13)

MSE equipment is almost identical at every echelon, thereby eliminating equipment compatibility problems. Another feature, a

dramatic departure from former procedures, is that all MSE terminal devices are user owned, user connected, and user operated. MSE employment doctrine is, however, designed to facilitate the user-owned and user-operated concept (FM 11-999F, 1987). The structure of signal units also changes with MSE and is discussed below.

2. MSE Structure and Organization

With the fielding of MSE, many of the operational levels of command between the corps signal brigade and the nodal platoons are effectively cut out (Johnson, 1987). This is another major change from the previous communications system and results in restructuring of signal units. Orders will be issued directly from the signal brigade to the nodal platoons. The platoon is a larger unit with much greater responsibilities than in the previous structure. The platoon, as the hub of the entire MSE system, will require DSS to effectively use the unit's resources. Chapter IV will focus on the automated support that is needed at the platoon level. First, the general MSE structure must be understood.

a. MSE General Structure

The MSE network is designed to provide communications to a corps area of about 37,500 square kilometers. Support for such an area is not an easy task and is centrally controlled by the corps signal brigade. The brigade, as seen in Figure 3-3, consists of an HHC, three corps area signal battalions, and one corps support signal battalion. Within HHC, the network control branch is mostly concerned

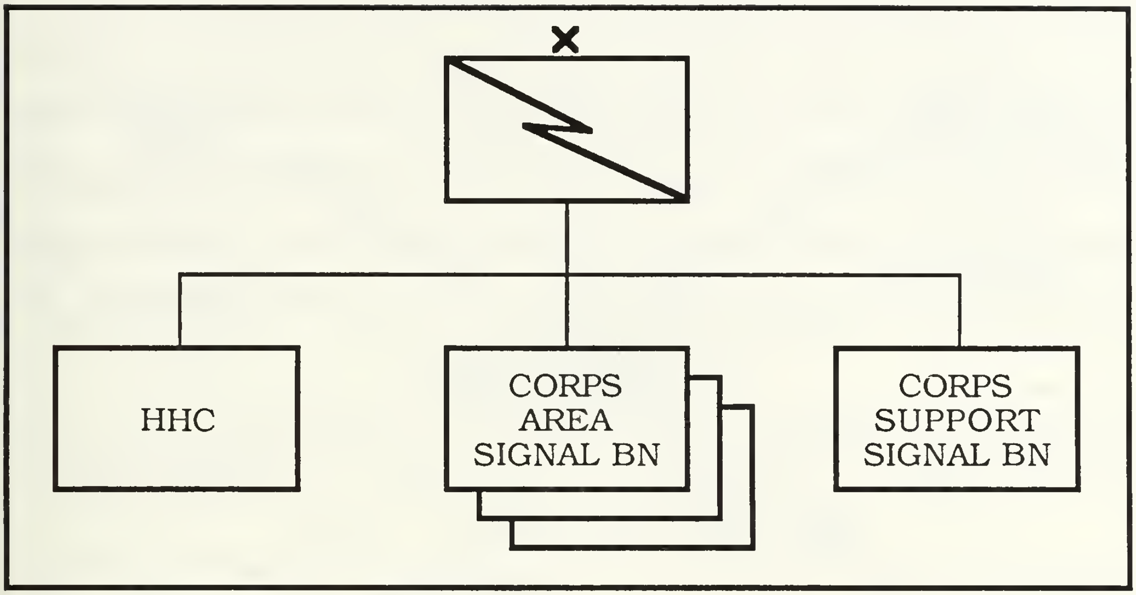


Figure 3-3. **Corps Signal Brigade** (FM 11-999F, 1987)

with the MSE network. This branch operates two system control center (SCC) facilities, one active and one standby. The SCC uses computer-assisted tools to make system management and control easier (Figure 3-4). The SCCs cannot, however, operate alone and must be linked to a node center switch (NCS) provided by one of the node platoons. (FM 11-30, 1987)

The corps area signal battalions are made up of an HHC, three identical area signal companies, and a signal support company. The area signal companies install, operate, and maintain two NCS sites and extension switch facilities to provide wire/mobile subscribers access to the MSE network. The companies actually perform the unit supply and maintenance functions with the company HHC while the communication mission is performed by the two nodal platoons. (FM 11-30, 1987)

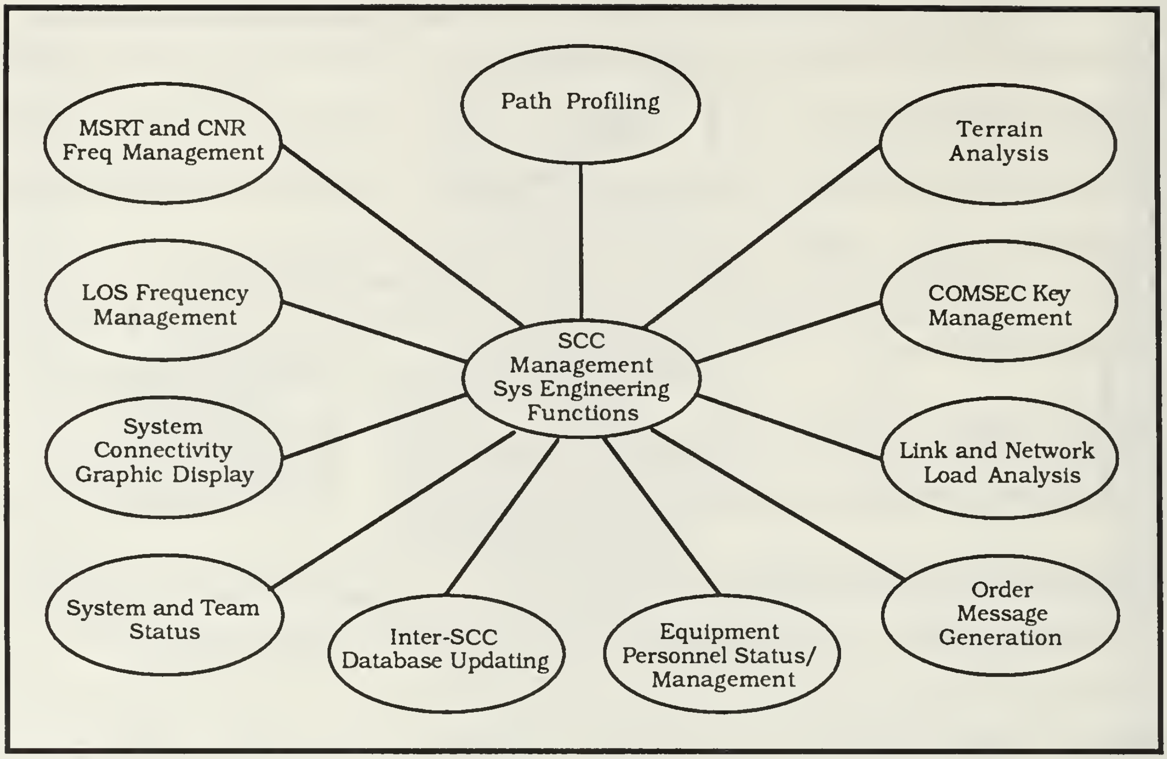


Figure 3-4. **System Control Center Functions** (Sherman, 1986)

b. Basic Building Block—The Nodal Platoon

The nodal platoon is the key element of the MSE system. The nodal platoons are organized into a headquarters, an NC section, and an extension switch section. Figure 3-5 provides a look at the personnel and equipment of the nodal platoon (FM 11-999F, 1987). These nodal platoons will perform the operational mission of the area companies and are standardized throughout the entire corps (Evans, 1986).

The platoon headquarters will contain a node management facility (NMF) which will provide the equipment and space to manage the resources seen in Figure 3-5. The only automated aid that the NMF has is the AN/UGC-74B teletype. The teletype provides the

capability to send status messages to the SCC and to receive operational messages and directives from the SCC (USASC, 1988). This limited automated support appears inadequate considering the critical responsibilities and large number of personnel and equipment that

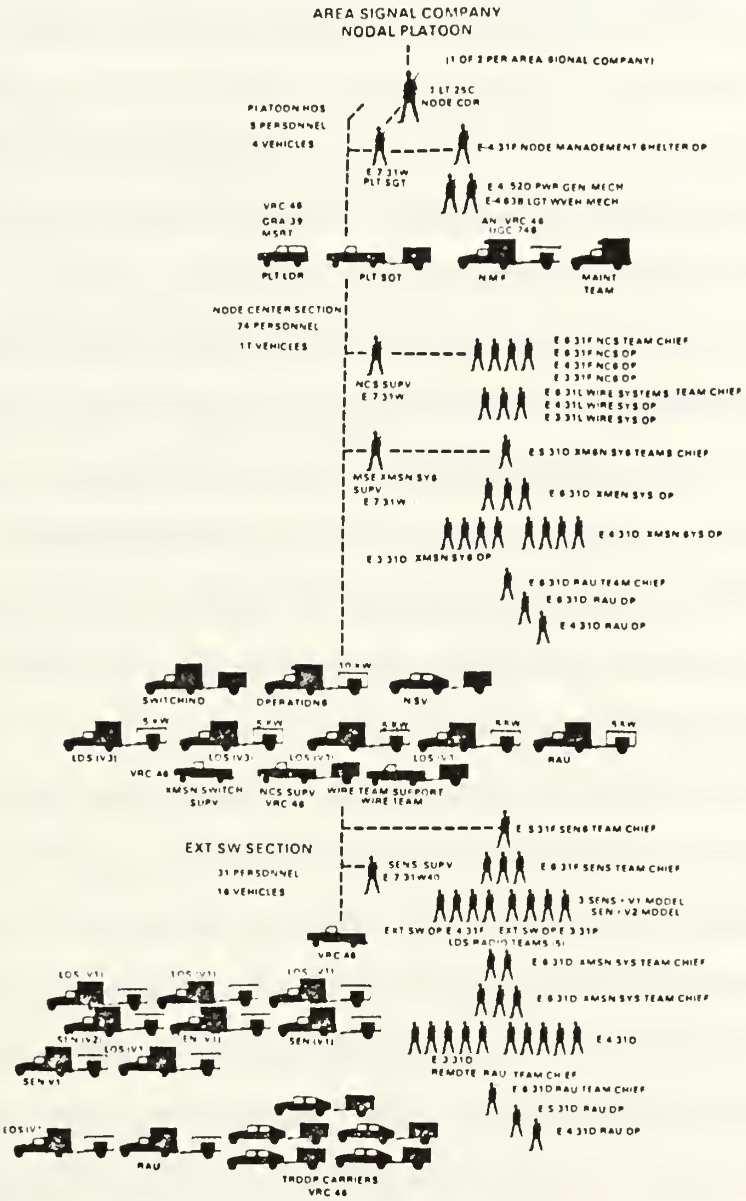


Figure 3-5. **Area Signal Company Nodal Platoon**
(FM 11-999F, 1987)

must be effectively managed in a battlefield environment. How can this environment be characterized and what are the responsibilities and decisions that the platoon leader or nodal commander will face?

3. Decision-Making Environment

Many of the decisions, with MSE, will be made under a very complex environment. The nodes will constantly "leapfrog" forward to provide continuous communications to the subscriber. One can get an idea of the fast-paced environment that MSE will encounter by looking at RITA (the French Army prototype system for MSE), where nodes displace every 72 hours. MSE node displacement will also experience this constant change. Because these nodes have to be independent and highly mobile, time-consuming planning is necessary for feeding soldiers, refueling, and maintaining equipment (Johnson, 1987). While resupply is a full-time responsibility for company and battalion headquarters, the platoon leadership must keep the SCC informed of supply, equipment, and personnel statuses.

The need for quick response in examining deployment considerations is also inherent with MSE. Rapid, expert decisions must be made regarding site selection, site reconnaissance, initial deployment, radio siting, site defense, and node displacement in order to provide uninterrupted communications services (FM 11-999F, 1987). These decisions have guidelines for standard support, but the decisions always must be evaluated based on the factors of mission, enemy, troops, terrain, and time (METT-T).

D. MSE DECISION MAKING

The platoon is the basic building block of the MSE system, and the platoon leader will therefore make critical decisions that directly affect communications service to subscribers. Some of these decisions are concerned with nodal displacement, resource management, and system control.

1. Nodal Displacement

The first reason for displacing an NC is the relocation of the subscribers. The main consideration in moving the NC is to ensure minimum disruption of service. The platoon leader provides the service by careful consideration of site selection, reconnaissance, logistics, and resource availability. (FM 11-999F, 1987)

a. Site Selection

The first consideration for site selection of an NC is that it should have line-of-sight access to a minimum of three other NCSs. The site must also have good omnidirectional VHF coverage for the local RAU. The actual area for the site layout should be small enough to allow for site defense and minimum cable use, but the assemblages should not be so close as to cause radio interference. An SHF radio must be used if the LOS radio is more than one mile from the switch. This separation would occur if the site was too small to accommodate all the equipment or for security reasons. This SHF "down the hill" radio deployment is shown in Figure 3-6. (FM 11-999F, 1987)

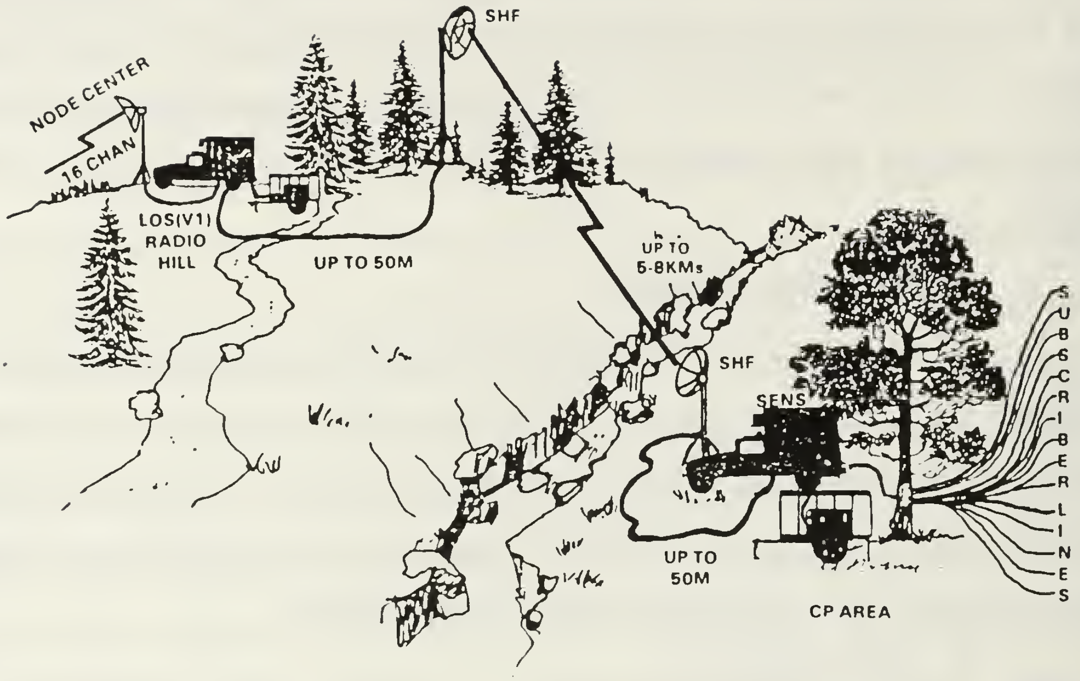


Figure 3-6. **SHF "Down-the-Hill" Deployment** (FM 11-999E, 1987)

b. Site Reconnaissance

In order to obtain high-quality communications, a thorough reconnaissance of the proposed location must be performed. Prior to the reconnaissance, the sites are plotted on maps, and the proposed line-of-sight shots are also plotted. During the reconnaissance, radio positions are plotted on the map considering access routes, direction of the tactical move, other units at the site, electronic warfare threat, and local radio frequency interference. Other points to be considered relate to site accessibility, concealment, radio

azimuths, and antenna location. The site should be drawn in detail and an alternate site should be selected for contingency operations (FM 11-999F, 1987). The entire reconnaissance process can take several hours and is often performed using only a map due to severe time constraints.

c. *Logistics*

The MSE system uses an area support concept for supply and maintenance. The corps area is divided into areas of responsibility, and support obligations are distributed among nine signal battalions making up the entire system. Each battalion furnishes signal supply and maintenance support to any signal element deployed in its designated area. The node platoon leader must maintain statuses on rations, POL, and communications supply support for NC sites, radio relays, remote RAUs, LENs, and SENs. These statuses must be forwarded to the appropriate unit to ensure continuous operations. (FM 11-999F, 1987)

d. *Resource Availability*

Because there will likely be personnel and equipment shortages in combat, the platoon leader must be able to quickly match unit assets to new mission requirements. He must understand all missions and be able to notify the SCC of any potential asset problems. The platoon leader may have to redistribute or commit equipment and personnel, as necessary, to accomplish the mission (FM 11-999F, 1987).

In order to effectively match unit assets to mission requirements, the platoon leader must be aware of personnel and equipment status. Having good dispatching techniques, sound maintenance procedures, and a standard reporting system will give the platoon leader a good feel for the assets available for future missions.

2. System Control

System control is established at a location which affords optimum control over a site. Once the NMF is operational, much of the control is accomplished by reporting, troubleshooting, and maintaining records. The reports are concerned with keeping track of links, equipment, personnel, traffic, and teams of the NC, LEN, SEN, RAU, and relays. Appendix A lists the reports. (FM 11-999F, 1987)

E. MSE SUCCESS FACTORS

In order for MSE to provide the flexible, reliable, and timely communications that are expected, there are five factors that are critical to MSE success. These critical success factors are concerned with the SCC software reliability, leadership at all levels, the team concept, maintenance procedures, and realistic training.

1. SCC Software Reliability

The corps' SCC software must be extremely reliable in order to properly manage the network level functions. The network is centrally managed, but much of the SCC success will depend on accurate reports from the platoon level. SCC also sends information and directives down to platoons; if this data is faulty, the network may experience numerous reliability problems until the platoons discover and

correct the fault through troubleshooting procedures. DSS could increase accuracy of the upward flow of reports and could also aid in the troubleshooting procedures if a problem did exist.

2. Leadership

Leadership at all levels will play an important role in MSE success. This leadership role must be supported and strengthened by leaders possessing a firm understanding of their equipment and personnel statuses, mission, requirements, capabilities, strengths, and weaknesses. This factor is especially important at the platoon level, the central point of the network, and this is where DSS will be extremely useful.

3. The Team Concept

The team concept will prove to be a factor that makes or breaks the flexible communication's effort. Standardization of MSE units will help support the moving battle by allowing teams to be interchanged as required rather than holding teams to strict, specific unit assignments.

4. Maintenance

Maintenance is the fourth MSE critical success factor. This involves preventive maintenance and troubleshooting at the lower levels, sound intermediate maintenance procedures at middle levels, and solid contractor support as required at higher levels. Equipment will inevitably have some problems in this type of environment, but if solid maintenance procedures are in place, quick equipment turnaround times can preclude major network degradation.

5. Realistic Training

Finally, realistic training to understand the new MSE equipment, new organizational roles, and new deployment concepts will certainly be a factor that is critical to success. Control has been centralized and many responsibilities have changed from the current tactical communications system.

6. Success Factor Summary

These five critical success factors point to the increased reliance on the platoon leader's ability to quickly assimilate large amounts of information to provide quality communications in his portion of the MSE network. DSS at the platoon level could certainly aid in achieving success of MSE.

F. SUMMARY

This chapter contains an examination of the Army's new communications architecture for the tactical arena. It was a much-needed change designed to support the AirLand Battle doctrine. The three systems of the architecture provide voice, data, and message traffic and give commanders a flexible media to aid in C^2. A probe of the corps common-user system has shown that the signal brigade centrally controls the MSE system with SCC's automated tools. The intermediate commands have been cut out of the operational level and have been reduced to serving administrative and logistical roles, and the platoon has emerged as the hub of the system. Only time will tell whether this restructuring will be effective.

The platoon leader's responsibilities and numbers of personnel have increased, and quality decisions must be made under great stress and time pressure. Nodes can be expected to displace at least every 72 hours; leaders will have to deal with this continuous change. These displacements require examination of many variables, such as the factors of METT-T. Yet, the platoon leader is given little automated support to aid in planning for the unit's critical communication mission.

This dynamic environment along with the MSE decision types are similar to those characteristics which were discussed in Chapter II and are capable of being supported by DSS. This thesis contends that DSS for the MSE platoon leader has been overlooked; it is argued that DSS would help platoon leaders make more effective decisions and would increase responsiveness to subscriber's needs.

The DSS proposed in the following chapter is intended to reduce the workload and increase effective use of resources to provide continuous communications to commanders. Chapter IV will further analyze the decisions made by the platoon leader and will put bounds on the domain of the proposed DSS. In addition, the DSS architecture will be developed by covering the proposed database, models, and dialog interface for the system.

IV. ANALYSIS AND DESIGN OF DSS FOR MSE MANAGERS

A. INTRODUCTION

Having presented the new Mobile Subscriber Equipment (MSE) communications system, this research now focuses on development issues of a specific decision support system (DSS) to maximize the capabilities of MSE's basic building block, the nodal platoon. The idea is to increase the effectiveness and speed of the decisions made by the MSE nodal platoon leader in order to provide timely, reliable, and flexible communications to tactical units in the corps area. The proposed DSS is not intended to replace the platoon leader or the signal brigade's System Control Center (SCC). Rather, it is designed to support the platoon leader's judgment and augment the functions of the SCC. This chapter analyzes the decisions and planning functions of the nodal platoon leader and develops a conceptual architecture of a DSS to support these functions. First, some of the assumptions and constraints concerning the people, technology, unit, and decision domain will be discussed.

B. ASSUMPTIONS AND CONSTRAINTS

1. People

a. Computer Literacy

As the signal corps takes on a larger role in managing information technology in the Army, the signal corps commandant, as reported in a 1986 *Army Communicator* article, has realized the

requirement for signal officers to be operationally and technically proficient as well as computer literate. The same publication in 1987 points to the push to educate signal officers.

> As the AirLand Battlefield becomes increasingly automated, signal officers without an automation background need to develop a functional understanding of microcomputers.

The Signal Officer Advanced Course has instituted microcomputer training to provide a working knowledge of how to use word processors, spreadsheets, databases, telecommunications, and graphics programs. For junior officers, local commanders are responsible for providing microcomputer training. It is evident from these comments that new technology in the form of DSS should not be a limiting factor for successful DSS use.

b. DSS Acceptance

As mentioned in Chapter II, acceptance of decision aids often meets with resistance due to preconceived notions that the aids are time consuming, and decision makers believe they do not need the help. Phelps asserts that it is generally accepted that one way to reduce the resistance is to get user involvement throughout the design effort. Phelps says that the military environment, however, has two factors that make user involvement difficult or impractical. First, the military experiences a very high turnover rate. Second, applications are often designed for a specific job, such as a commander or, in this case, a platoon leader, rather than for a specific person. (Phelps, 1986)

Phelps offered one solution to this problem by implementing the aid in training situations where resistance is least. The student can be taught the assumptions, constraints, and concepts behind the aid. When he is assigned to an operational unit, the individual is already aware of the aid and acceptance is less of an issue (Phelps, 1986, p. 217). The Signal Officer Basic course, for new lieutenants, is an excellent environment to provide this DSS and microcomputer training to "break in" a new system while simultaneously fulfilling its normal communications training mission.

2. Technology

One of the biggest problems in developing DSS up to now was the technology limitation. The first DSS were geared toward solving the structured problems that were associated with a particular organizational function, such as finance, and there was little emphasis on "user friendliness" in operating the systems. Currently, Maclean and many other researchers agree that more emphasis is being placed on the critical man-machine interface. (Maclean, 1986, p. 102)

Microcomputers are playing an increasingly important role by reducing development costs and giving users confidence and higher expectations for easy-to-use systems (Maclean, 1986, p. 101). Portable computers are also having a great influence on pushing automation to nontraditional areas. Portable computers are particularly useful in the military environments, where they can be moved easily, quickly set up, and immediately torn down. They can be connected to high-quality monitors when the situation permits or can use the attached screen

while on the road. The proposed DSS should use the most current, off-the-shelf equipment but should be compatible with the available communications systems.

3. Unit

This research will refer to interactions between the nodal platoon and the corps signal brigade's SCC. Similar types of interactions, however, will take place between the division SCC and its nodal platoons. This paper also seems to ignore the battalion and company levels. This is not to imply that DSS will not be appropriate at these levels, but in the relevant literature, their communications planning and management roles are not clearly defined with the MSE system.

4. Decision Domain

The platoon leader is responsible for 60 personnel and large amounts of equipment dispersed over several locations. The proposed DSS is concerned with assisting in the planning and decision making at the platoon level. This paper limits its design considerations to supporting planning and decision making regarding site selection, situation analysis, and troubleshooting. This could be expanded, but during the process of writing this thesis, only the first phase of MSE was being fielded at Fort Hood, Texas, so analysis of planning and decision making came from the author's tactical signal experience and from the newest coordinating drafts of MSE field manuals.

C. ROMC SYSTEM ANALYSIS

In developing the ROMC approach, Sprague and Carlson noted that decision makers have trouble describing the actual process they

go through, but they do rely on conceptualizations and memory aids during the process. Another observation is that the decision-making process phases are interrelated and interleaved and these operations will not always be carried out in the same sequence. They also pointed out that decision makers want to maintain direct control over their support (Sprague and Carlson, 1982). This section looks at the representations, operations, memory aids, and controls that should be provided for in a nodal platoon leader's DSS.

1. Representations

As discussed in Chapter II, representations help decision makers conceptualize a problem. The first type of representation the platoon leader requires in planning for displacement of assets is the military map. The map is used in decisions that deal with such areas as terrain analysis, route selection, site selection, troubleshooting, and antenna placement.

The map is used not only for the decision-making process but also to communicate the concept to others. Figure 4-1 gives an example of a map representation that can be used for terrain analysis and line-of-sight (LOS) determination. Other instances of representations that were discussed in Chapter II and which the platoon leader requires are:

- Data entry forms—used for various requests or for maintaining a log of events.
- Reports—used for internal and external reporting for communications statuses, administration, logistics, or security.

- Spreadsheets—used for tracking systems, maintenance, and logistics.
- Lists—used for deployment checklists to insure critical areas are not neglected.
- Notepad—used for miscellaneous calculations and for taking notes.

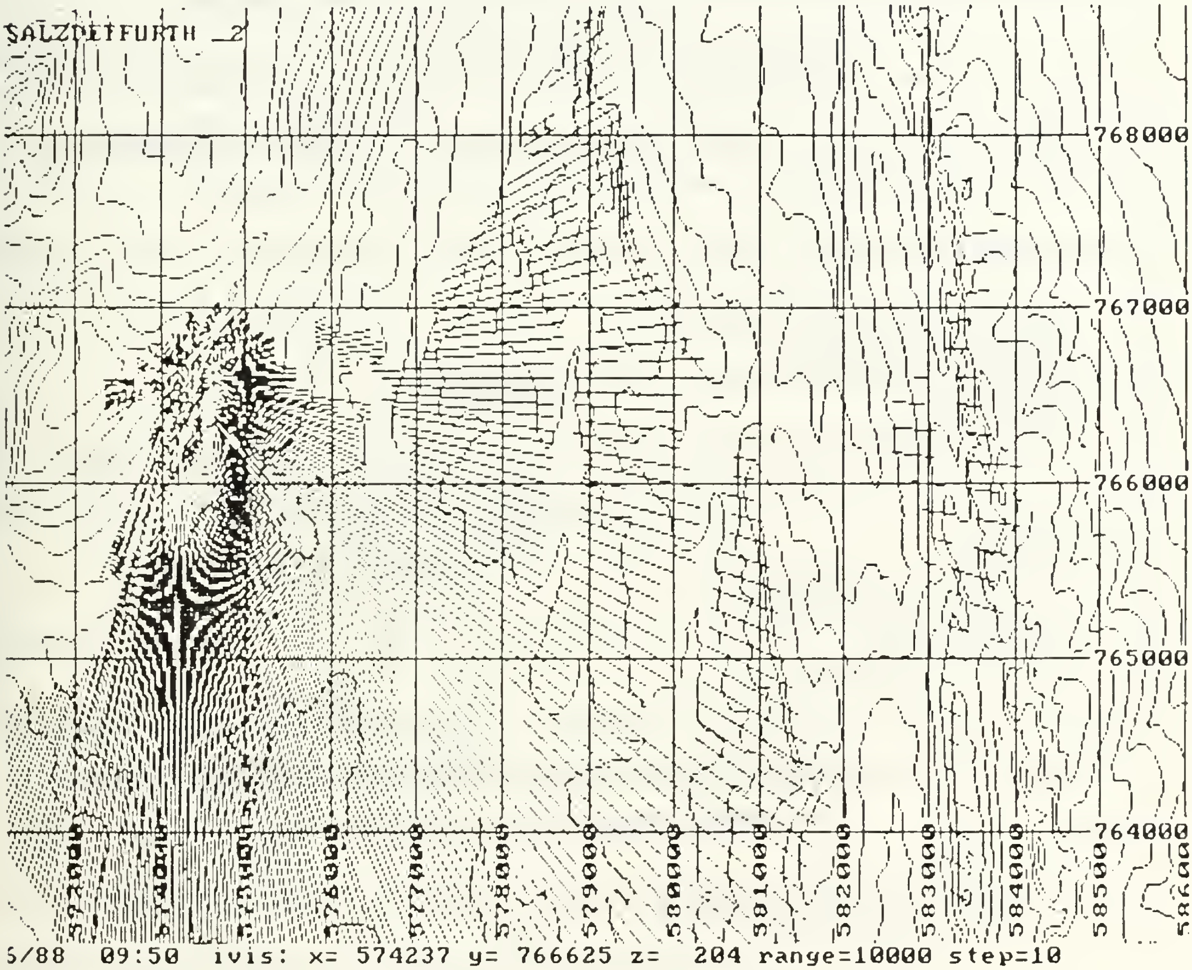


Figure 4-1. **Map Representation for LOS Determination Adapted from BDM Corporation's Battle Planner Toolkit**

2. Operations

In considering selection of operations, it is useful to again turn to Simon's intelligence-design-choice paradigm for decision

making. For example, Figure 4-2 depicts the operations associated with each phase of the decision-making process for site selection.

Operations must be provided to be able to manipulate each of the representations discussed earlier in this chapter. Some of the principal operations for the proposed DSS are listed below.

Operations for Site Selection Decision Making

INTELLIGENCE

- gather data from SCC and other sources
- select appropriate maps
- select relevant portion of data
- validate data
- plot data on maps

DESIGN

- set objectives for site selection
- develop measures for objectives
- plot data on maps
- generate alternative plans

CHOICE

- generate statistics on each site alternative
- plot potential sites on a map
- select a site
- plot data on a map
- disseminate plan to subordinates

Figure 4-2. **Operations Used in the Decision-Making Process for Site Selection Consideration**

a. Map Operations

These operations include selection of appropriate digitized military maps, map zoom, LOS calculations, distance calculations, route analysis, situation analysis, and use of overlays or templates.

b. Data Entry Forms

These operations are concerned with providing interactive, standardized, easy-to-use forms for requesting food, fuel, network

information, maintenance service, data verification, and spare parts. These forms could also be used for logging activities for later analysis.

c. *Reporting*

These operations facilitate retrieval, completion, and output of standard and exception reports. A listing of reports that concern the node center are presented in Appendix A.

d. *Spreadsheet*

Spreadsheet operations facilitate keeping track of maintenance, asset management, system status, team status, and site status.

e. *Checklist*

Checklist operations make it easier to retrieve checklists for various tasks such as node displacement, troubleshooting, site selection, or daily operations. Checklists ease the memory requirements of the user and prevent him from omitting critical factors or considerations.

f. *Notepad*

Notepad operations are concerned with taking miscellaneous notes or jotting down ideas generated from meetings or discussions with superiors, adjacent units, or subordinates. They can be indexed and called up at any time in the future.

3. Memory Aids

Memory aids are provided to ease the memory load of the platoon leader by aggregating and interpreting information. These memory aids will be easily retrievable in order that the platoon leader will not have to learn a new language and can spend more time on the

problem than on the machine. The proposed DSS will use several types of memory aids listed by Sprague and Carlson:

- Database—both internal and external databases are used to compile and manipulate data relevant to communications planning. These databases are concerned with personnel, equipment, terrain, systems, friendly units, enemy, and mission.

- Work spaces—used to temporarily store representations that are produced by operations.

- Libraries—used to save representations that have been manipulated for later use.

- Triggers—reminders for the platoon leader to send reports or perform some other action.

- Profiles—used to store default settings for maps, forms, reports, etc.

- Views—the system must be able to provide different views of the same data. Examples include subsets and transformations that are common to many database management systems.

4. Control Mechanisms

There are several control mechanisms that should be incorporated into the DSS to support the use of the system. The MSE DSS should make use of menus and function keys to control the system and should have a mouse or trackball capability to facilitate this control. Also, extensive use of help messages with simple explanations should be built into the system to allow the platoon leader to easily work his way through the system while always knowing where he is.

D. ARCHITECTURE

The data-dialogue-model conceptual model is used in this section to help in consideration of DSS design issues. This thesis focuses on

top-level design issues to serve as a basis for further development of the idea of providing DSS to MSE nodal platoon leaders. Figure 4-3 depicts the conceptual framework of the proposed DSS. It shows the required connections between the data component, model component, and dialogue component, and indicates the requirement for a communication link to external sources.

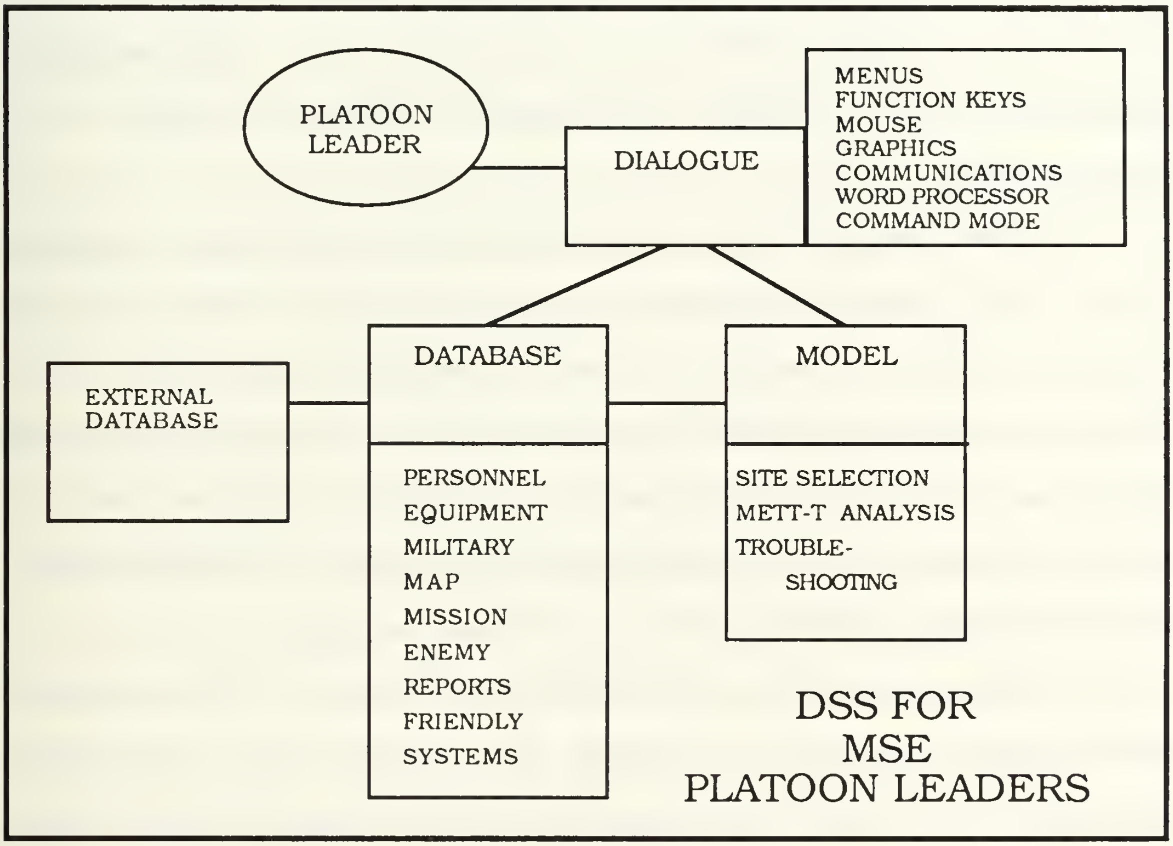


Figure 4-3. **Framework of the DSS for MSE Platoon Leaders**

The basic system concept is for the nodal commander to use the database and various models to support his decision-making and planning functions for various operations by having direct interaction with the dialogue component. Because the decisions made do not have a

sequential method, the platoon leader can use the menus or command language to maneuver through any part of the system depending on the situation. Each of the elements of the proposed system is now discussed.

1. Data Component

The data component requirements are examined in this section using the criteria developed by Sprague and Watson and explored by Garnto and Watson. These criteria include source, time criticality, aggregation, level of detail, and degree of accuracy (Garnto and Watson, 1985).

Data that is used for MSE decision making and planning comes from external sources (e.g., SCC, extension switches, LOS relays, and radio access units) as well as internal sources (e.g., NMF and co-located assemblages). Although some of the flow of data is sent and received by voice, it is important that the data elements that are passed electronically are standardized at the brigade level. The information flow for the MSE network can be seen in Appendix B.

The data must be up to date in order to be of any use to the platoon leader. Likewise, the brigade SCC requires timely information from the node centers to manage the entire network, so the data exchange should be easy and quick to perform to provide the most timely information available. On the other hand, some historical data will be used for terrain analysis and other map-related operations. This terrain data should be locally maintained at the NMF.

Another requirement for the data component is data reduction. Aggregation of the large amounts of information is needed in order for the platoon leader to be able to form quick and knowledgeable judgments without having to wade through detailed data. For instance, instead of looking through a large listing of equipment and personnel to see if assets exist for a new mission, the platoon leader can simply look at a combination of his assets to quickly make a determination.

Different levels of detail should also be maintained in the database in order to be able to ask detailed questions rather than just relying on aggregated data. Finally, the data used in the DSS must be accurate to give the platoon leader a reliable aid.

The data component shown in Figure 4-4 illustrates the database management system and the connection to the external SCC database and the attachment to other internal databases and other components of the DSS. The database management system performs the common operations using extracted data from any of the attached databases. This extracted data can then be used by the various models and dialogue components to give the platoon leader the decision support required. Appendix C provides additional information on the databases.

2. Model Component

The model component of the DSS contains the models that the platoon leader will use during the planning and decision-making

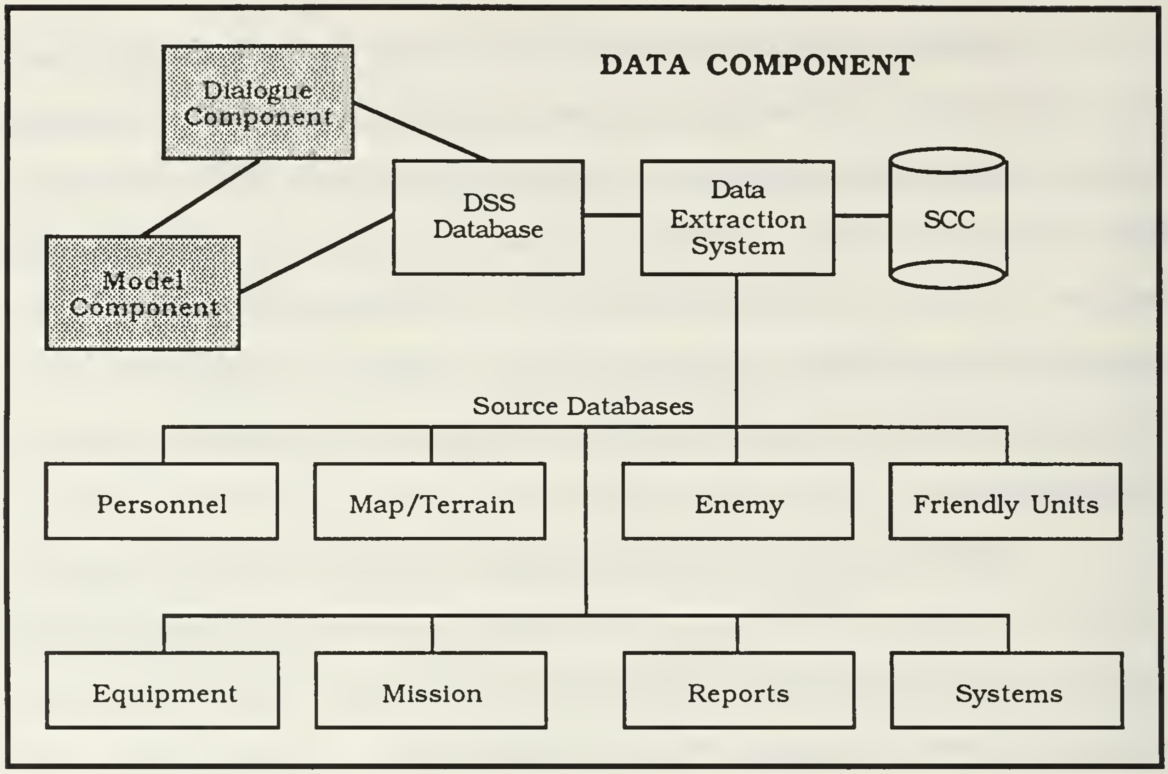


Figure 4-4. **An Overview of the Data Component of the Proposed MSE DSS**

process. Figure 4-5 shows how the model component interfaces with the database and dialogue components. The models in the DSS will be stored as subroutines and programs as suggested by Sprague and Carlson's research. These models are the operations that can be performed on the maps, reports, spreadsheets, and other representations. The link with the database allows the models to use and return data to the database. It is important to point out that output to be displayed comes from the data-dialogue line while "the model-dialogue link is used to facilitate the building and the operation of the model by the builder." (Sprague and Carlson, 1982, p. 274)

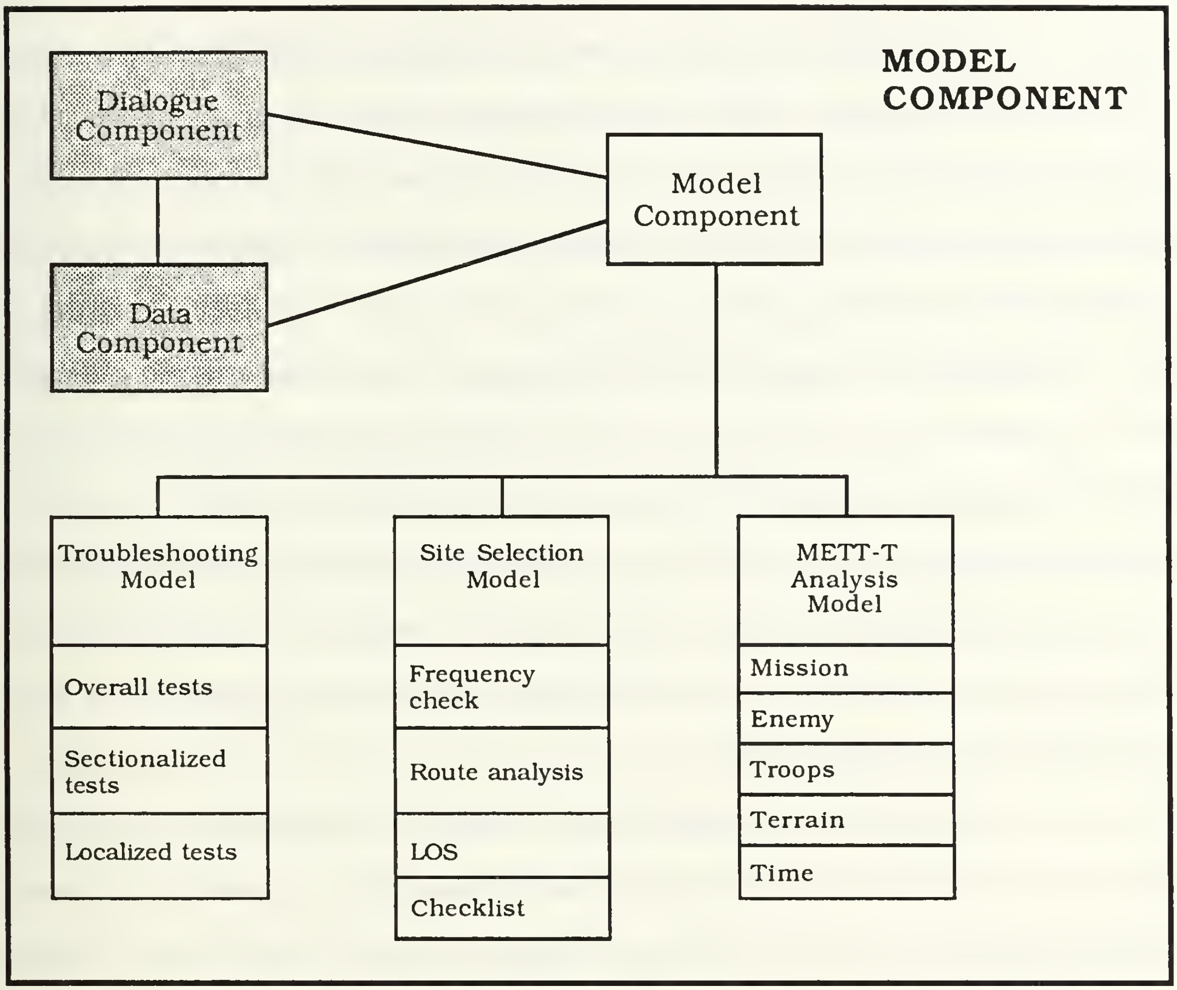


Figure 4-5. **An Overview of the Model Component**

a. Site Selection Model

The main idea behind the site selection model is to let the platoon leader verify data from the OPORD and to analyze his courses of action upon receipt of movement instructions from the brigade SCC. Optimal placement of a node center depends on good LOS to at least three other NCs. After the correct map is retrieved, a cross-hair icon can be placed at a proposed location and entered for processing LOS and distance to produce screen output similar to

Figure 4-1. After LOS, distance, and azimuths are checked, the best route must be selected. This is determined based on such factors as enemy, road type, terrain, time, and distance. The model will then perform simulation based on given parameters and will suggest primary and alternative sites and routes. Several vendors in industry have developed this type of route simulation. The model should also be able to perform analysis to determine whether an SHF "down-the-hill" link is required. This calculation is based on the size of the proposed location, distance to subscribers, equipment availability, and security (e.g., necessity for masking emanations). Issued frequencies and polarizations are then checked against other known systems in the area for possible interference.

Video disk technology should be considered for site reconnaissance. This would actually allow the entire reconnaissance to be performed in minutes without leaving the NMF. The output from this model would include strip maps, site diagrams, and system diagrams which could then be disseminated to the appropriate teams.

b. METT-T Analysis Model

When analyzing a situation, the platoon leader must consider and understand all the elements of METT-T. He should be aware of specified and implied tasks and should be able to quickly match unit assets to mission requirements. This model should detect potential problems in meeting the mission in terms of the five elements of this model and should help the platoon leader consider the potential impact of these elements on the current situation. A full analysis may

be somewhat time intensive, so the model should be able to easily extract the critical issues and transform them into graphics or templates to be superimposed on the appropriate map screen. If more time is available, the platoon leader can consider more detailed information through the menus or command language. Much of the data used by this model will be extracted from the brigade databases.

c. *Troubleshooting Model*

The troubleshooting model would be used when the radio operator of the controlling terminal cannot isolate a system outage or cannot correct a marginal system. These circuit problems are generally of two types: circuit degradation or circuit failure. Yavorsky explains in his thesis that circuit degradation is concerned with fading, static, and loss of signal strength and may result from weather conditions, dirty equipment filters, electronic warfare, or faulty equipment. Circuit failure is caused by power loss, extreme weather, electronic warfare, or equipment failure. (Yavorsky, 1987, p. 20)

The troubleshooting model uses a systematic approach to isolating and identifying the above-mentioned communications problems. The platoon leader would use this model to ensure that a prescribed troubleshooting method is maintained, to avoid the omission of critical steps, and to support his cognitive limitations.

Three types of tests make up this model: overall tests, sectionalized tests, and localized tests (FM 24-21, 1974, p. 14-4). This model deals with a relatively defined domain and makes use of a set of rules to determine or infer problems. After determining the problem,

the model could then suggest appropriate corrective action. The platoon leader would examine appropriate steps to take and relay the instructions to the appropriate communications assemblage. This model would minimize the time to reestablish a quality system.

3. Dialogue Component

The dialogue component allows the platoon leader to easily and transparently interface with the data and models to aid his decision-making abilities. It also gives the user the ability to see the representations (e.g., maps, graphics) and control the system.

a. Action Language

The platoon leader will use a standard keyboard to communicate with the system by using menus, function keys, and a command language. Simple function key meanings should be able to be displayed or turned off by the user. Also, a mouse or trackball can be used to speed the operations of the entire system. The user must also be able to use the external communications link with a minimal amount of keystroke manipulations.

b. Display Language

The display language, what the platoon leader will picture, consists of a high-resolution color monitor to display detailed maps with overlay and templates. Windows should be used to allow for multiple views of information. The printer is also considered part of the display language and should be capable of printing graphics and text to support the output of all representations.

c. *Knowledge Base*

In order for the DSS to be used effectively, the user must have ample knowledge. The platoon leader should have sufficient training on microcomputers and on the DSS to understand the reasoning behind the calculations. The system should be user friendly, but initial training will help with acceptance if the user can easily learn his way through the DSS, allowing him to know "where he is" at any given time. A user's manual must accompany the DSS to support users at all levels of experience, and the DSS should also use extensive on-line help facilities to assist the user.

4. Description of the Computer

Considering the capabilities and characteristics of the proposed DSS presented above, what should the actual computer look like? This section considers this question to point out the feasibility of the proposed system in terms of current technology and provides a description of the platoon leader's computer—its dimensions, portability, color, speed, power, and capacity.

The computer should be compact and portable. A ruggedized laptop would be suitable for this environment to allow the platoon leader to carry out his functions in the NMF, in a vehicle while on the road, or outdoors while a new site is being set up. Figure 4-6 shows how a platoon leader might use the system. Current laptops weigh from 11 to over 20 pounds and are typically portable in a small briefcase. Since the 1970s, the Army has been developing ruggedized cases

for computers which enhance transportability in a tactical environment (Metz, 1988).

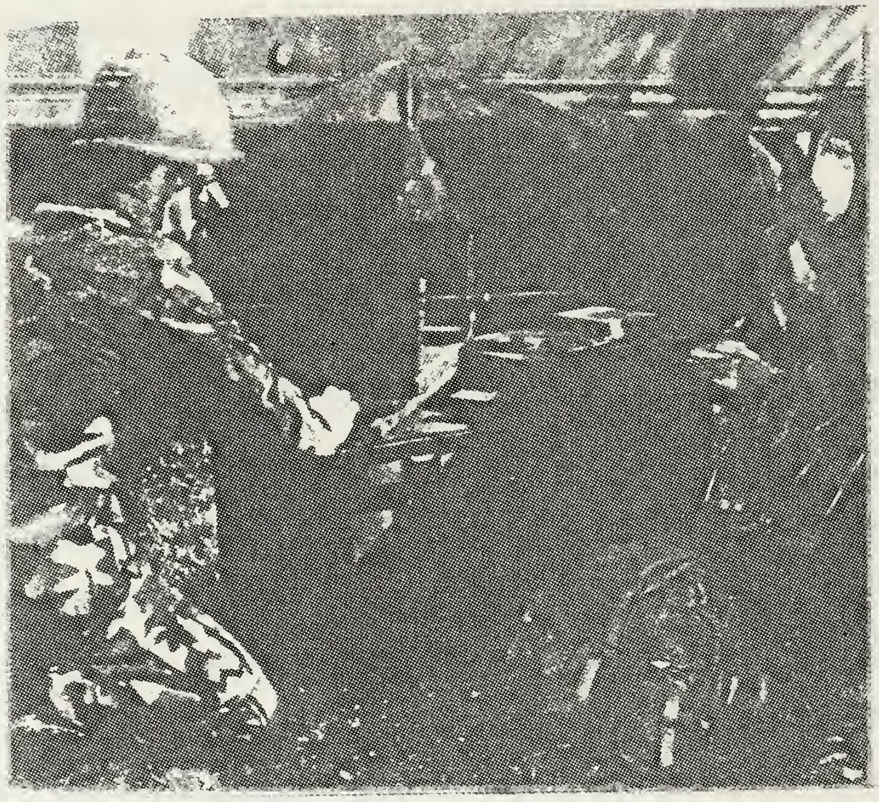


Figure 4-6. **How a Platoon Leader Might Use the System**

The monitor should be capable of displaying high-quality, color graphics, mainly for analyzing maps. Current portable computers use high-resolution liquid crystal displays or gas plasma displays but have adapters for external color monitors, but flat panel technology is on the verge of producing color monitors for portables (Metz, 1988).

Processing speed is another important capability to consider. Many of the DSS functions will call for time-consuming data accesses, calculations, and simulations. This need can be met with existing commercial laptops which are based on 80286 microprocessors and have operating speeds of up to 12 megahertz.

The DSS will be used in situations where an electrical power source is not available, therefore the computer must have the capability to use battery power for up to 15 hours. Several existing commercial laptops provide this battery power capability.

The proposed DSS will use large amounts of data. Computer disk read-only memory (CD-ROM) is a relatively new technology that should be considered. Currently, CD-ROMs have capacities of 550 megabytes and can hold 100,000 pages of typeset information. Technical graphics will take up a considerable amount of this capacity, but bit-mapped or vector graphics can be used to compress images (Strukhoff, 1988). This would allow extensive storage and use of digitized map data, technical manuals, field manuals, and standard operating procedures which have previously taken up too much space or were simply left in garrison. Although CD-ROM is presently impractical for use with portable computers, it could be used in the NMF as a peripheral drive.

The computer must have connections for access to the tactical communications system (two or four wire) and must also conform to military standards for electrical power, tempest, wide temperature

ranges, high humidity, shock, vibration, salt, sand, dust, and rain (Metz, 1988).

E. SUMMARY

This chapter contains an analysis of the planning and decision-making process of the MSE nodal platoon leader by looking at his requirements for representations, operations, memory aids, and controls. In light of this analysis, the paper then looked at design considerations and requirements for a proposed DSS by looking at its three components: data, dialogue, and models. A generic description of the platoon leader's computer was then presented to show the feasibility of the proposed DSS in terms of current technology. The purpose of the DSS is to support the nodal platoon leader's planning and decision-making process by bolstering his cognitive limitations, accelerating his analysis process, increasing his decision effectiveness, and by allowing him to spend more time on "making it happen." The DSS could strengthen the heart of the MSE system, thereby equipping battlefield commanders with more timely, reliable, flexible, and mobile communications.

The next chapter presents some conclusions that are drawn as a consequence of this study of the new MSE system and the analysis and design of DSS for the lowest echelon of that communications system.

V. CONCLUSIONS AND RECOMMENDATIONS

A. CONCLUSIONS

This section contains conclusions concerning the Mobile Subscriber Equipment (MSE) system and Decision Support Systems (DSS) for MSE leaders. These conclusions are presented in order to provide input to the evolution of MSE and to give insight for possible continuation of studies concerning development of DSS for communications managers.

The author was motivated to write this thesis because of the recognition of the need for Decision Support Systems at the node center of the Army's MSE network. MSE is a new communications system that is expected to enhance the corps area common-user system and thereby provide increased flexibility and reliability to combat, combat support, and combat service support units. The communications system will heavily rely on the signal brigade's system control center (SCC) for overall network management, but MSE will also bank on the decision-making skills and leadership of platoon leaders at the 42 node centers to make the new technology a success.

After reviewing relevant DSS literature and the latest MSE field manuals (1987), it became apparent to the author that tactical signal organizations will be restructured. The company and battalion levels are no longer as involved in the planning and decision-making process of providing communications, and their roles in communications

management are quite vague in the field manuals and reviews on the subject. The explanation comes from the centralized nature of the MSE deployment concept, but to whom will the brigade commander turn when a system is not operational—the platoon leader?

Most of the network management information flow is directly from the brigade to the platoon, which is quite a dramatic departure from the previous system. Therefore, the author focused on providing support to the platoon leader. The nodal platoon leader has an increased responsibility with a reduced "buffer" between him and the brigade level. The platoon leader must, therefore, assimilate great amounts of information without the assistance of his immediate higher headquarters. This situation lends support to the idea of providing DSS to aid the platoon leader in quickly verifying data, analyzing the situation, making a decision, disseminating a plan, and providing useful feedback and reports to the brigade network managers.

There were some constraints on the extent to which the proposed DSS could be developed in this thesis. The MSE system is new and has only begun to be fielded, so direct user contact was not possible and analysis was mainly based on relevant articles, coordinating draft field manuals, and the author's tactical communications experience. This limitation, along with time constraints, resulted in no attempt being made at performing detailed design requirements. This paper did, however, provide design issues and capabilities for a specific DSS that could be used for consideration in future work.

B. RECOMMENDATIONS

First, commenting on MSE, it is a new system and will undoubtedly experience many modifications from the original plan as it evolves. One area that should be more clearly defined in the manuals is the role of the company and battalion as far as their responsibility in planning and management of the network. Information flow goes directly from brigade to platoon, which goes against the grain of the chain of command.

There are many areas of research that can be done in continuation of developing DSS for tactical communicators. Further analysis must be done at field sites because the MSE system is now being fielded at Fort Hood, Texas. Since MSE is in its infancy and the idea of DSS for its platoon leaders is also new, requirements can only be understood and benefits achieved through iterative analysis and design with the users. Iterative design of the DSS undoubtedly will result in additions and deletions of capabilities and characteristics.

Other issues that must be examined include correct placement of DSS in the organization, control and management of the DSS, responsibility for database administration, data standardization, training, and maintenance.

Another possible direction of this system comes from artificial intelligence and expert systems. Currently, these technologies have only been applied in areas with very bounded domains, but they should not be overlooked. Expert systems process the knowledge of experts by using heuristic problem solving instead of optimization and formal

reasoning (Ford, 1985) and would be suitable for most of the procedures within the proposed DSS, such as troubleshooting, data verification, route analysis, checklists, and situation analysis.

Continued research in providing DSS to tactical communications managers is vital considering the demands of commanders on the fast-paced battlefield. Commanders will expect a transparent communications media to be able to synchronize their efforts and assets, and the Signal Corps must provide it. It is necessary to afford junior, often inexperienced leaders with all the modern technology available to help in the overall goal of providing battlefield commanders with timely, reliable, and flexible communications so that they can win in combat.

APPENDIX A

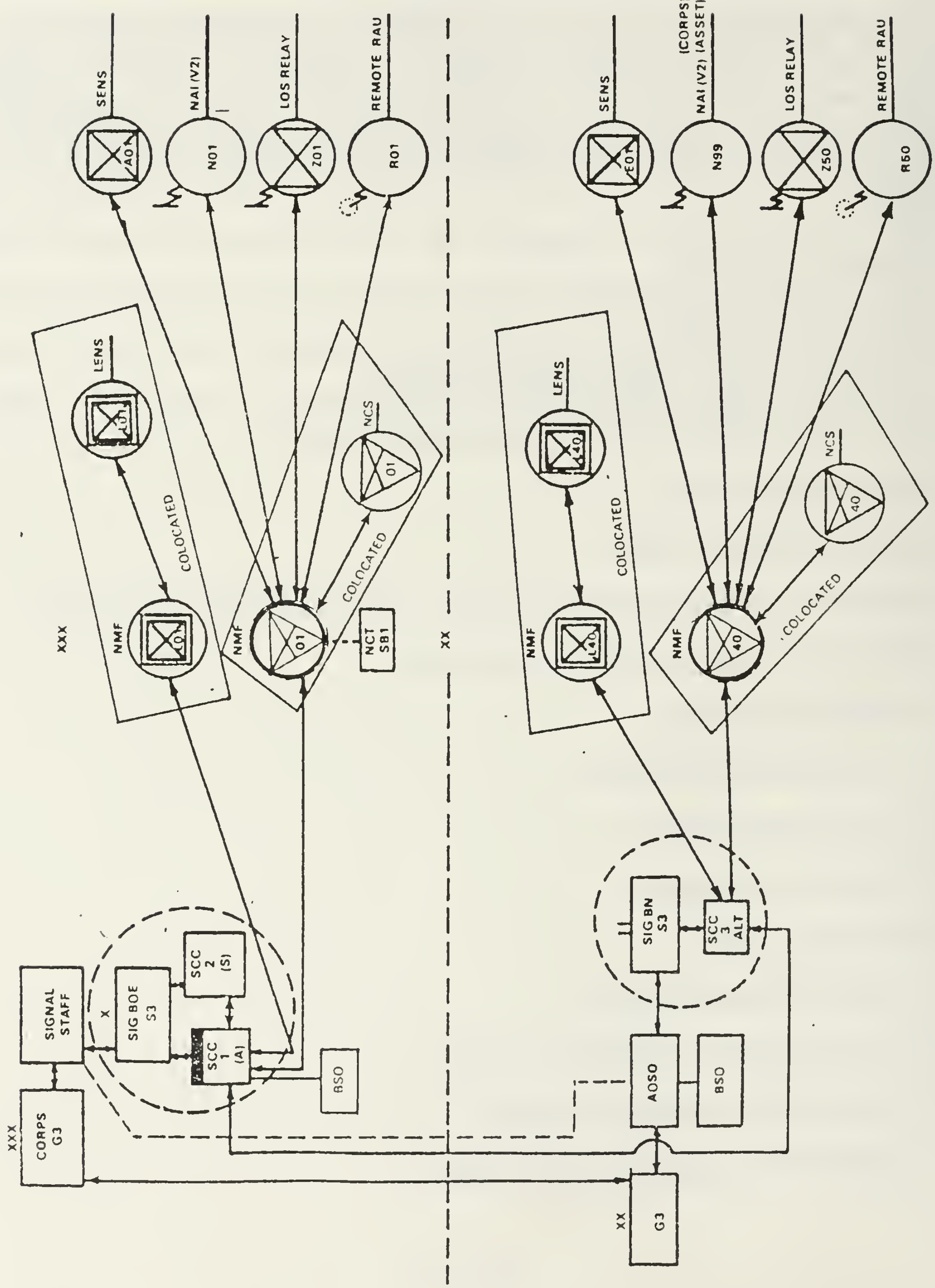
REPORTS/MESSAGES CONCERNING THE NODE CENTER

The following messages are used to update the system control center and are generated by the node center. They are preformatted and should be integral to the design of the proposed Decision Support System.

- Open link report
- Close link report
- Close NC, LEN, SEN, RAU, NIT report
- NC, LEN, SEN, RAU, NIT relay failure report
- Link outage report
- Link saturation report
- Return to normal use for NC, LEN, SEN, RAU, NIT relay report
- Return to normal use for link report
- Equipment report
- Personnel status report
- Team status report
- Request for support
- Incident report
- Traffic metering report
- Key generation complete message
- Key transfer complete message
- MSRT/RAU frequency plan request

APPENDIX B

MSE INFORMATION FLOW



APPENDIX C

DATABASE INFORMATION

Database	Responsibility for Update	Frequency of Update	Contents of the Database
Personnel	Platoon leader or his representative	Every 12 hours or as required	Name, SSN, rank, sex, team, status, specialty, rotation date
Map/Terrain	Defense Mapping Agency, Plt ldr	Maps are historical, Other data (templates) daily and as required	1:50,000 and 1:250,000 maps, manmade, water, contour, elevation, distances
Equipment	Platoon leader or his representative	Every 12 hours or as required	Vehicle type, shelter type, components, status, team, identification number
System	Platoon leader or his representative	Updated as data changes or received	Azimuth, frequency, location, polarization, status, channels, control terminal, unit supported
Friendly	Platoon leader or his representative	Every 12 hours or as required	Friendly unit, type, location
Enemy	Platoon leader or his representative	Upon OPORD receipt, every 12 hours	Enemy unit, type, threat, location
Reports	Platoon leader or his representative	As required	See Appendix A
Mission	Platoon leader	Upon OPORD receipt	Situation, mission, execution, command and control, support

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